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Distribution and biomass of capelin, Arctic cod and sand lance on the Northeast Newfoundland Shelf and Grand Bank as deduced from bottom-trawl surveys

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Abstract

Changes in the distribution and trawlable biomass of capelin (*Mallotus villosus*), Arctic cod (*Boreogadus saida*) and sand lance (*Ammodytes* sp.) are deduced from their by-catches during standard resource assessment bottom-trawl surveys in Divisions 2J3KL during the autumn and in Divisions 3LNO during the spring. Three different bottom trawls were used during the study period (1978-1999), and the estimates of biomass changed substantially with each change in gear. In particular, biomass estimates increased dramatically starting in the autumn of 1995 when the Engel 145 Hi-rise trawl was replaced by the Campelen 1800 shrimp trawl. There has been no attempt to conduct comparative fishing experiments for these three species with these two trawls, so the change in gear represents a break in the timeseries for each species. In general, Arctic cod were found mainly toward the coast in Divisions 2J3K, capelin were found throughout the area and exhibited seasonal changes in distribution, and sand lance were found only on the plateau of Grand Bank. The most notable changes in distribution involved a move toward the southeast in Division 2J3K by both capelin and Arctic cod in the early to mid-1990s. In 1998-1999 both species appeared to be returning to distributions seen in the 1980s. Other notable features include an increase in the trawlable biomass of Arctic cod in the early to mid-1990s and a decline in the trawlable biomass of capelin during the same period.

Résumé

Des changements dans la répartition et la biomasse chalutable du capelan (*Mallotus villosus*), du saida (*Boreogadus saida*) et du lançon (*Ammodytes* sp.) ont été déduits à partir des prises accessoires de ces poissons lors de relevés courants au chalut de fond effectués à l'automne dans les divisions 2J3KL et au printemps dans les divisions 3LNO. Durant la période d'étude (1978-1999), trois chaluts de fond différents ont été employés et les estimations de biomasse ont beaucoup varié à chaque changement d'engin. En particulier, les estimations de biomasse ont énormément augmenté à partir de l'automne 1995 lorsqu'on a remplacé le chalut Engel 145 Hi-rise par le chalut à crevettes Campelen 1800. Comme on n'a pas tenté de réaliser des expériences de pêche comparée des trois espèces avec les deux types de chaluts, les changements d'engin constituent une rupture dans la série chronologique pour chaque espèce. En général, le saida se trouvait surtout près de la côte dans les divisions 2J3K, le capelan était réparti dans toute la région d'étude et présentait des changements de répartition saisonniers, tandis que le lançon était capturé seulement sur le plateau du Grand Banc. Le déplacement du capelan et du saida vers le sud-est dans les divisions 2J3K lors de la première moitié des années 1990 a constitué le changement de répartition le plus remarquable. En 1998-1999, les deux espèces semblaient revenir à leur répartition des années 1980. Par ailleurs, la biomasse chalutable du saida a augmenté dans la première moitié des années 1990, tandis que celle du capelan a diminué durant cette période.

Introduction

Small planktivorous fish might influence recruitment to stocks of Atlantic cod (*Gadus morhua*) in two major ways. As predators, they may consume the eggs, larvae or very small juveniles of the cod. As prey, they may through changes in their abundance or availability influence the quantity of food consumed by mature cod and thereby influence the quantity or quality of the eggs and sperm produced by the cod stock. To assist in study of the effect that changes in the biomass of small pelagics might have had on the dynamics of northern (2J+3KL) cod, the relative abundance and distribution of small pelagics is described from their by-catch during standard resource assessment bottom-trawl surveys in 2J3KL during the autumn and 3LNO during the spring.

The major small planktivorous fish inhabiting shelf waters from southern Labrador to the southern Grand Bank are capelin (*Mallotus villosus*), Arctic cod (*Boreogadus saida*), herring (*Clupea harengus*) and sand lance (*Ammodytes* spp.). Capelin and herring are objects of directed commercial fishing and subjects of directed scientific study and assessment, whereas Arctic cod and sand lance are not fished and have received much less scientific attention. All four species are important prey for larger fish, marine mammals and birds (Bundy et al. 2000).

Capelin has historically been the dominant pelagic species in the area and the major prey of cod. In the early 1990s capelin almost disappeared from Division 2J, increased in abundance in areas where they were previously uncommon (Flemish Cap and eastern Scotian Shelf), became inaccessible to acoustic surveys conducted at traditional times, arrived late in the inshore for spawning, and experienced low growth rates (Lilly 1994; Frank et al. 1996; Nakashima 1996; Carscadden et al. 1997; Carscadden and Nakashima 1997). In the past 2-3 years there are indications that some aspects of capelin biology, notably their offshore distributions, appear to be changing to more closely resemble patterns observed in the 1980s (Anon 1998; DFO 1999). The status of the 2+3KL capelin stock remains uncertain, although most year-classes produced in the 1990s appear strong relative to those produced during the 1980s (DFO 1999).

Herring stocks along the east coast of Newfoundland tend to be coastal in distribution. They are currently at low levels relative to peak levels in the mid-1970s (DFO 1998).

Arctic cod, a cold water species, has historically been found along the Labrador Shelf and in the coastal regions of the Northeast Newfoundland Shelf, mainly off the Northern Peninsula and within White Bay. Arctic cod appeared to increase in abundance and expand its distribution during the early 1990s (Lilly et al. 1994; Lilly 1996). Although large individuals up to 6 or 7 years of age are well represented in catches on the northern Labrador Shelf, most individuals on the southern Labrador Shelf and the Northeast Newfoundland Shelf have been smaller individuals of ages 0 to 2 (Lear 1979; Wells 1980).

Sand lance occurs in small populations along the coast and as a large population on the plateau of Grand Bank (Winters 1983). Inshore and offshore populations may belong to different species, although the species compositions and nomenclature remain unclear (Winters and Dalley 1988).

Capelin, Arctic cod and sand lance are frequently caught during bottom-trawl surveys directed toward demersal fish off southern Labrador and eastern Newfoundland. The distribution and magnitude of capelin catches from the surveys in Divisions 2J, 3K and 3L during the autumn and spring have been compared with geographic coverage by acoustic surveys for capelin to help determine whether coverage by the acoustic surveys has been adequate and to provide supporting data on changes in capelin distribution (Lilly 1999 and references therein). In addition, abundance and biomass estimates have been routinely presented. In contrast, the by-catch information on Arctic cod has only occasionally been presented, and has not been updated for several years. By-catch information for sand lance has not been examined since the mid-1980s.

The purpose of this paper is to document changes in the relative biomass and distribution of capelin, Arctic cod and sand lance as deduced from their by-catch during standard resource assessment bottom-trawl surveys. It will be shown that the information available for these species has increased dramatically since the autumn of 1995 when the Campelen 1800 shrimp trawl replaced the Engel 145 Hi-rise trawl as the standard gear in these surveys.

Materials and Methods

Bottom-trawl surveys

Stratified-random bottom-trawl surveys have been conducted by Canada during autumn in Divisions 2J, 3K and 3L since 1977, 1978 and 1981 respectively and during spring in Divisions 3LNO since the early 1970s. The survey stratification scheme (Doubleday 1981; Bishop 1994) was based on depth intervals intersected by lines of latitude and longitude. Set allocation was proportional to stratum area, with the provision that each stratum be allocated at least 2 sets. The most notable change in survey coverage was the addition of depths between 100 and 200 m in northwestern Division 3K (St. Anthony Shelf and Grey Islands Shelf) in 1984 and subsequent years. Additional strata were added to the inshore in Divisions 3K and 3L in 1996-1998 to provide additional insight into distribution and abundance of organisms landward of the standard survey area.

Five ships and three different bottom-trawls were deployed at various times during the surveys (McCallum and Walsh 1997). In all instances, a 29 mm mesh liner was inserted in the codend.

Autumn surveys: All surveys in Division 2J and 3K in 1978-1994 were conducted with the 74 m stern trawler *Gadus Atlantica*. Surveys in Division 3L in 1981-1983 and 1985-1999 were conducted with the 51 m side trawler *A. T. Cameron* (1981-1982) and the sister 50 m stern trawlers *Wilfred Templeman* (1983, 1985, 1987-1999) and *Alfred Needler* (1986). There

were no autumn surveys in Division 3L in 1978-1980 and 1984. The *A.T. Cameron* deployed a Yankee 41-5 trawl whereas the *Gadus Atlantica*, *Wilfred Templeman* and *Alfred Needler* deployed an Engel 145 Hi-Lift trawl until 1994. Starting in 1995 the *Gadus Atlantica* was replaced by the 63 m stern trawler *Teleost* and the Campelen 1800 shrimp trawl with rockhopper foot gear was deployed from both the *Teleost* and the *Wilfred Templeman*.

Spring surveys: Surveys were conducted with the *A. T. Cameron* (1971-1982) and the *Wilfred Templeman* (1985-1999) and *Alfred Needler* (1984). The *A. T. Cameron* deployed a Yankee 41-5 trawl, and the *Wilfred Templeman* and *Alfred Needler* deployed an Engel 145 Hi-Lift trawl until 1995. Starting in 1996 the *Wilfred Templeman* deployed the Campelen trawl.

Fishing protocol: Fishing in all Divisions and years was conducted on a 24-h basis. Prior to autumn 1995, tows were made at 3.5 knots for 30 min. Starting in autumn 1995, tows were made at 3.0 knots for 15 min. Catches from the few tows of non-standard duration were appropriately adjusted.

The variability in ships and bottom-trawls may have resulted in differences in catching efficiency, but this possibility has not been examined for capelin, Arctic cod and sand lance. Comparative fishing experiments in 1995 and 1996 demonstrated that the selectivities of the Engel and Campelen trawls were markedly different, with the Campelen being far more effective at catching small fish (Warren 1997).

Distributions

The distributions of capelin, Arctic cod and sand lance are presented in expanding symbol plots, as opposed to contour plots generated from modeling of the catches, in order to provide visual information on the spatial distribution of fishing stations, among-station variability in catch, and the relationship between catches and bathymetry. Catches from surveys prior to autumn 1995 are presented as kg per standard 30 min tow, whereas catches from surveys from autumn 1995 onward are presented as kg per standard 15 min tow.

Estimation of biomass

The biomass of each species in each stratum was estimated as

$$W_h = \frac{A_h \sum_{i=1}^{n_h} W_{hi}}{a n_h}$$

where W_{hi} is the weight (kg) of that species in the catch of set i ($i = 1, 2, ..., n_h$) in stratum h, and a is the area sampled by a standard tow. The biomass in each Division was obtained by summing over strata.

Results

Distributions of capelin and Arctic cod in Divisions 2J3KL during autumn (Fig. 1,2)

During the 1980s, capelin tended to be aggregated in two broad areas, one in the northwest of Divisions 2J and 3K and the other in northern and northeastern Division 3L. Within the northern group, the capelin were often found in both Division 2J and Division 3K but in some years (e.g. 1986, 1987) the capelin had already migrated into central Division 3K by the time the survey was conducted. After about 1990 or 1991 the distribution shifted to southeastern Division 3K. In 1997 the distribution was still concentrated toward the southeast but with some indication of a return to the west. In 1998 and 1999 the distribution was similar to that seen in 1986 and 1987.

Through the 1980s Arctic cod were found primarily in the shallow, cool water toward the coast in Divisions 2J and 3K, but starting in about 1991 they were found further to the east and south. This southward extension seemed to peak in 1995, after which the Arctic cod returned to a distribution similar to that seen in the 1980s.

Distributions of capelin and sand lance in Divisions 3LNO during spring (Fig. 3,4)

In most years of the 1980s, capelin were found in an arc around the northern Grand Bank, with largest catches in the Avalon Channel and on the Nose of the Bank. Catches declined precipitously in 1991 and remained very low until 1996, when good catches were secured everywhere in Division 3L except on the plateau of the bank. It is not clear how much of this change was due to the change to the Campelen trawl and how much was due to a return by the capelin to the migration timing and behaviour seen in the 1980s. Capelin were also caught in some years near the Tail of the Bank. The stock affinities of these capelin are not clear. They may belong to the 2+3KL stock or the 3NO stock.

Sand lance were caught in good quantities on the plateau of Grand Bank in years prior to 1983, but with the change from the Yankee 41-5 trawl to the Engel trawl in 1984 they almost disappeared from the surveys. They reappeared in even larger quantities when the Campelen trawl was introduced in 1996.

Estimates of biomass

The minimum trawlable biomass of capelin as determined from autumn surveys was extremely low in 1978, relatively high in 1979-81, and fluctuated without trend from 1982 to 1994 (Fig. 5). The high levels in Division 2J in 1978-1981 were due almost entirely to a few very large catches on the plateau of Hamilton Bank (Carscadden et al. 1989). The estimates increased dramatically with the introduction of the Campelen trawl in 1995, and have ranged from 29,000 t in 1996 to 68,000 t in 1995 and 1998. The 1999 estimate was 32,000 t.

The minimum trawlable biomass of capelin as determined from spring surveys was variable during the late 1970s and the 1980s (Fig. 6). The biomass was very low in Division 3L from 1991 to 1995, but a relatively large quantity was found in Division 3O in 1993. Since the introduction of the Campelen trawl, estimates have ranged from 20,000 t in 1997 to 95,000 t in 1996. The 1999 estimate was 81,000 t.

The biomass of Arctic cod as determined from autumn surveys was less than 2000 t in years prior to 1992, with the exception of 1985, 1988 and 1989 (Fig. 7). The reason for the peak in 1985 is not clear, but the cold water in that year may have had an influence. The high levels in 1988 and 1989 were due to the very strong 1987 year-class (Lilly et al. 1994). Biomass increased in the early 1990s as several additional strong year-classes appeared. The time course of events in the next few years is somewhat obscured by the change to the Campelen trawl in 1995. Since 1995, the biomass estimates have ranged from a high of 93,000 t in 1996 to a low of 21,000 t in 1999.

Biomass estimates of Arctic cod in Division 3L were variable in the spring during the 1980s but more consistently high during the 1990s (Fig. 8). Since the introduction of the Campelen trawl, estimates have ranged from a high of 9,000 t in 1996 to a low of 600 t in 1998. The 1999 estimate was 960 t.

The biomass of sand lance as determined from autumn surveys was about 2000 t in 1981-1982, declined to extremely low values during the period when the Engel trawl was used (1983-1994) and then increased to as high as 165,000 t with the introduction of the Campelen trawl in 1995 (Fig. 9).

Biomass estimates of sand lance in the spring on Grand Bank were variable and as high as 30,000 during 1978-1982, declined to extremely low levels while the Engel trawl was used (1984-1995) and increased to as high as 300,000 t with the introduction of the Campelen trawl (Fig. 10).

Discussion

How useful are by-catches in bottom-trawl surveys as indicators of distribution and relative biomass of small pelagic fish? Perhaps of the three species considered in this paper, Arctic cod is the most amenable to study with a bottom-trawl because it tends to be semi-demersal from age 1 onward.

The above question has been considered with respect to capelin because the bottom-trawl surveys have the potential of providing considerable insight into the biology of this commercially important species, covering as they do large areas during seasons when other sources of information on capelin are not available. It is useful to consider the question in two steps: (1) how well does the estimate of biomass reflect the quantity of capelin in the trawl survey area at the time of the survey and (2) how does the latter reflect the total abundance or biomass of the capelin stock? With respect to part (1), Lilly (1995a) found that both the frequency of occurrence and the trawlable biomass calculated for the spring series in Division 3L were positively (but not significantly) related to the biomass of capelin estimated from the spring acoustic surveys. The lack of significance may be due in part to poor overlap in time and space between the acoustic survey and the bottom-trawl survey. More information is needed on the relationship between catches in a bottom trawl and the density and behaviour of capelin in the immediate vicinity as measured and observed with hydroacoustics. It is possible that a large catch of capelin in a bottom trawl indicates a high density of capelin near the bottom, especially since large catches are frequently taken close together, often in sequential sets. However, large catches could occur when the survey encounters capelin in relatively shallow water. For example, large catches of capelin on Hamilton Bank in 1979-81 (Carscadden et al. 1989) contributed to high estimates of trawlable biomass at a time when Soviet and Canadian acoustic surveys indicated that the abundance of the SA2+Division3K capelin stock was low (Lilly 1994). It is also possible that changes in the behaviour of capelin may alter their vulnerability to a bottom trawl. For example, if capelin tend to stay near the bottom in both night and day, instead of migrating upward at night as has often been observed, then they may be captured more frequently and in greater quantities. Shackell et al. (1994b) reported that the capelin found during the acoustic survey of Division 3L in spring 1992 were relatively deep and did not surface at night as in previous years. Such behaviour might result in an upward bias in the frequency of occurrence and the estimate of biomass.

The second part of the question relates to the distribution of the capelin at the time of the bottom-trawl survey. Frank et al. (1996) reported that capelin increased in abundance outside their normal range during periods of anomalously low sea temperatures. They speculated that these changes in distribution, particularly the appearance of capelin on the Flemish Cap, could explain, in part, the dramatic decline in estimates of capelin abundance from spring acoustic surveys beginning in 1991. Such large-scale migrations to areas outside Division 2J3KL could affect bycatches in both the spring and autumn bottom-trawl surveys. Bycatches in the spring survey might also be affected by changes in the timing of the capelin migration relative to the timing of the survey. Both the timing of the capelin migration into southern Division 3L and the timing of their spawning on beaches of eastern Newfoundland are variable and related in part to changes in water temperature (Shackell et al. 1994a, Nakashima 1996, Carscadden et al. 1997). In addition, the time of the spring bottom-trawl survey in Division 3L has become retarded by about one month in recent years compared with the 1980s. This delay in the survey might increase the degree of spatial overlap with capelin if the capelin migration is also delayed, but the degree of overlap cannot be assessed.

It is of interest that the distribution of capelin may be seen far more clearly in plots of the occurrence of capelin in the stomachs of those cod caught in the bottom-trawl surveys than in plots of the capelin by-catches themselves (Lilly 1994; Lilly 1995b).

A problem that has not been addressed in this study is the possibility that fish may move during the course of the survey. The maps (Figs. 1-4) do not necessarily represent a synoptic picture of distribution. The best illustration of the problem is the distribution of capelin in 3LNO in spring. In several years, notably 1986 (Fig. 3e) and 1990 (Fig. 3g), large catches of capelin were taken on the northern side of the 3L/3O boundary and almost none were caught on the southern side. This is caused by the pattern of the survey and the migration pattern of the capelin. The spring surveys generally start in northwestern 3O, progress across the southern Grand Bank, and then enter 3L. A few weeks may pass between fishing on the southern side of the 3L/3O line and fishing on the northern side. During this period, capelin may migrate into the area, mainly from the northeast.

One would like to use by-catches during bottom-trawl surveys to provide information on long-term changes in distribution and relative abundance of pelagic species. Although much can be inferred from the distribution plots and relative biomass estimates provided in this paper and elsewhere, there remains the problem of what appear to be large differences in catchability among the three bottom-trawls used in these studies. In terms of their ability to catch capelin, Arctic cod and sand lance, the Campelen is clearly the best and the Engel is the worst. This difference is most apparent with sand lance (Fig. 10). There were no attempts to include these species in the comparative fishing studies conducted between the Engel and the Campelen during 1995 and 1996. Even if such studies had been attempted, they may have been of only limited value, because the Engel caught almost no sand lance and relatively few of the smaller sizes of capelin and Arctic cod. The positive aspect of the change in gears is that much more information on capelin, Arctic cod and sand lance is accumulating since the adoption of the Campelen trawl in autumn 1995.

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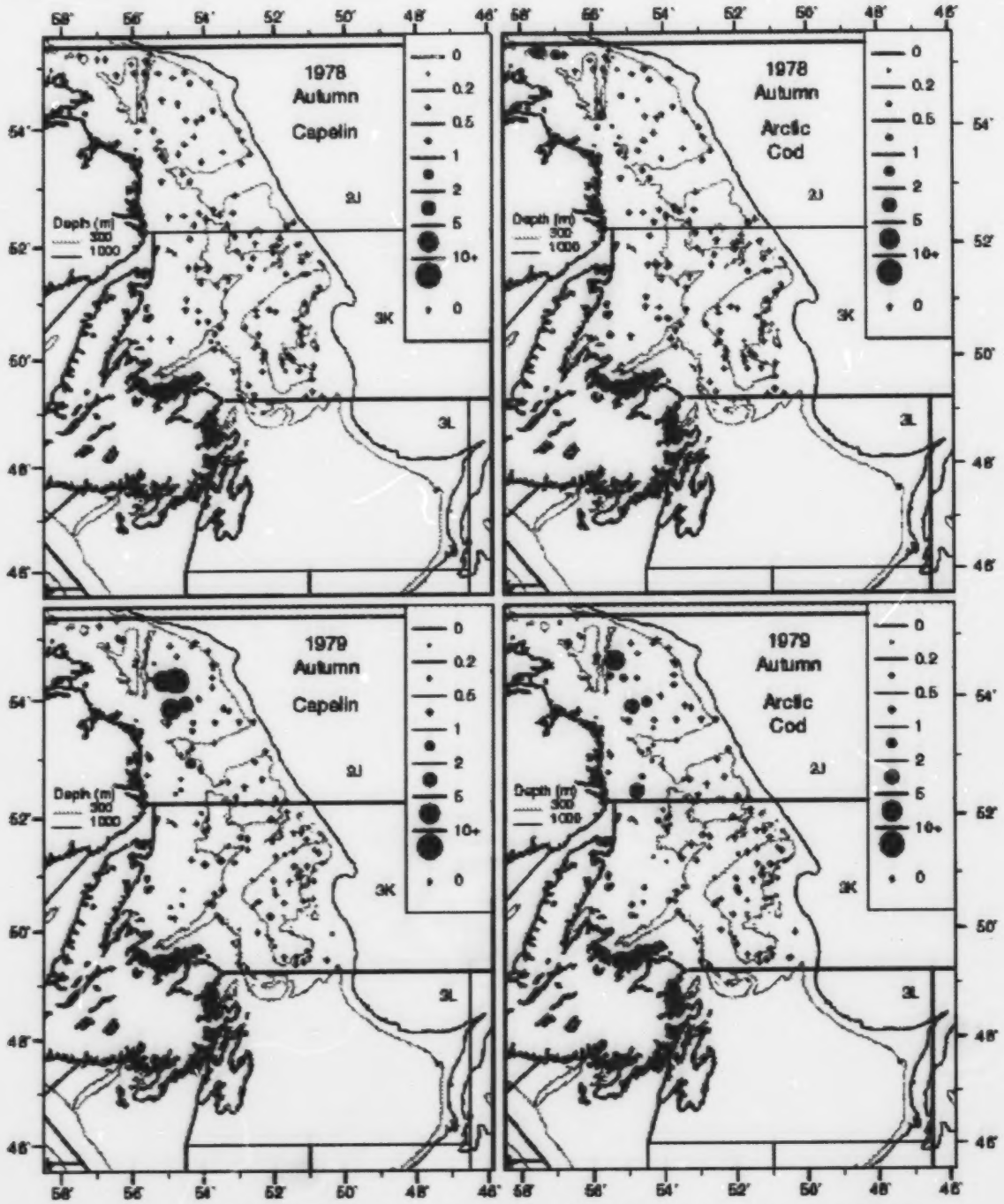


Fig. 1a. Geographic distribution [kg per 30 min tow (1978-1994) or 15 min tow (1995)] of capelin and Arctic cod in Divisions 2J3KL during the autumns of 1978 and 1979.

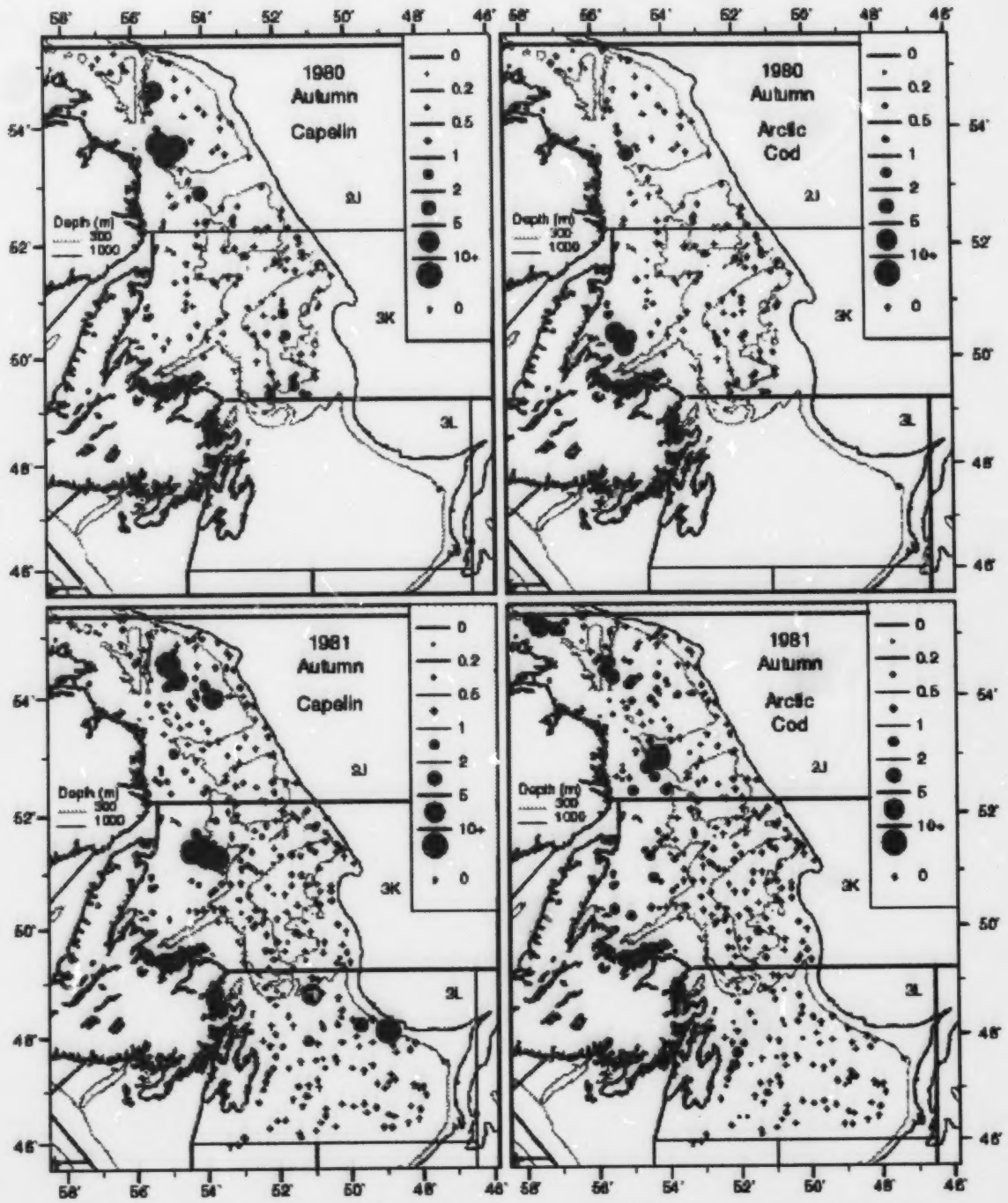


Fig. 1b. Geographic distribution [kg per 30 min tow (1978-1994) or 15 min tow (1995)] of capelin and Arctic cod in Divisions 2J3KL during the autumns of 1980 and 1981.

Fig. 1c. Geographic distribution [kg per 30 min tow (1978-1994) or 15 min tow (1995)] of capelin and Arctic cod in Divisions 2J3KL during the autumns of 1982 and 1983.

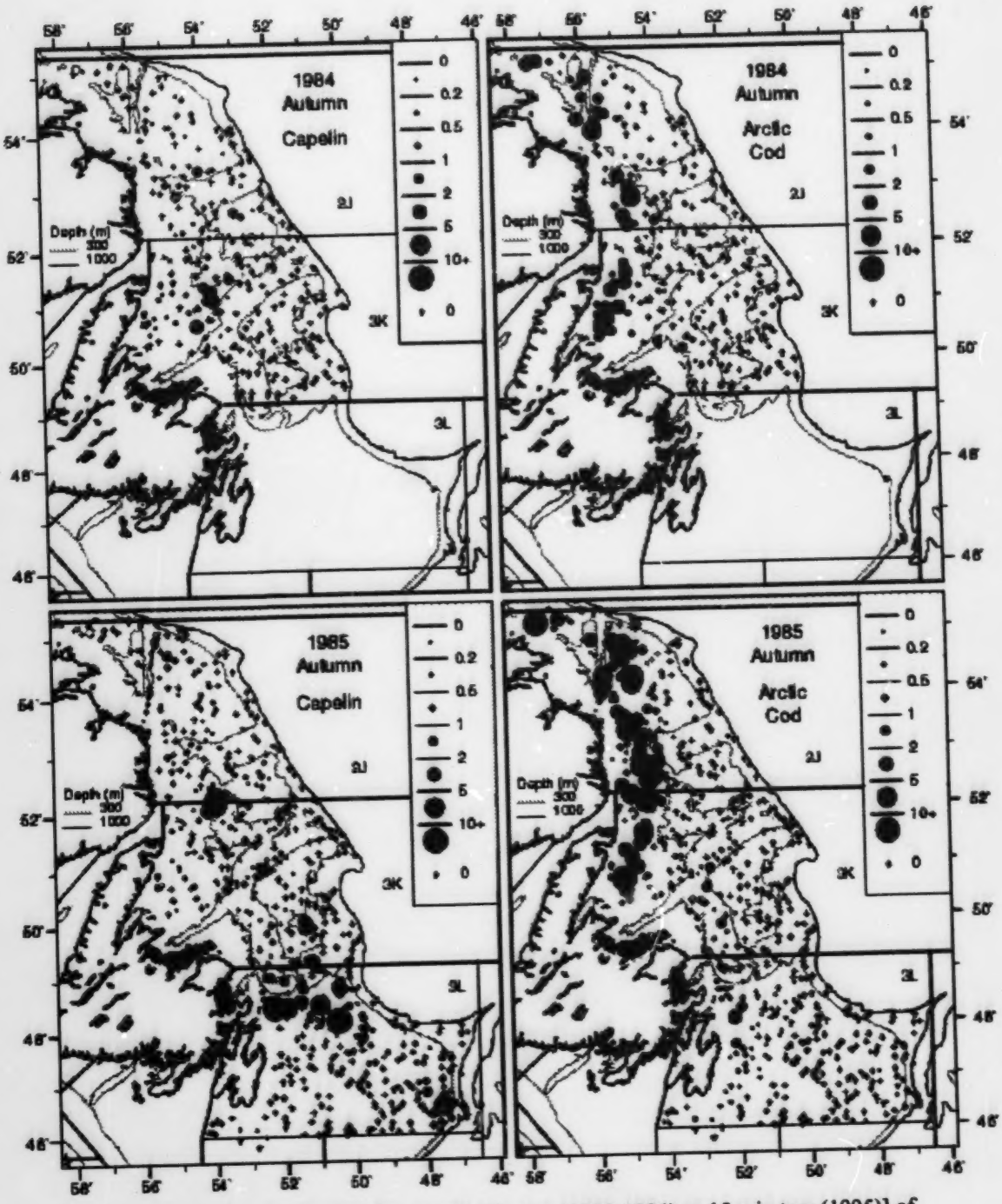


Fig. 1d. Geographic distribution [kg per 30 min tow (1978-1994) or 15 min tow (1995)] of capelin and Arctic cod in Divisions 2J3KL during the autumns of 1984 and 1985.

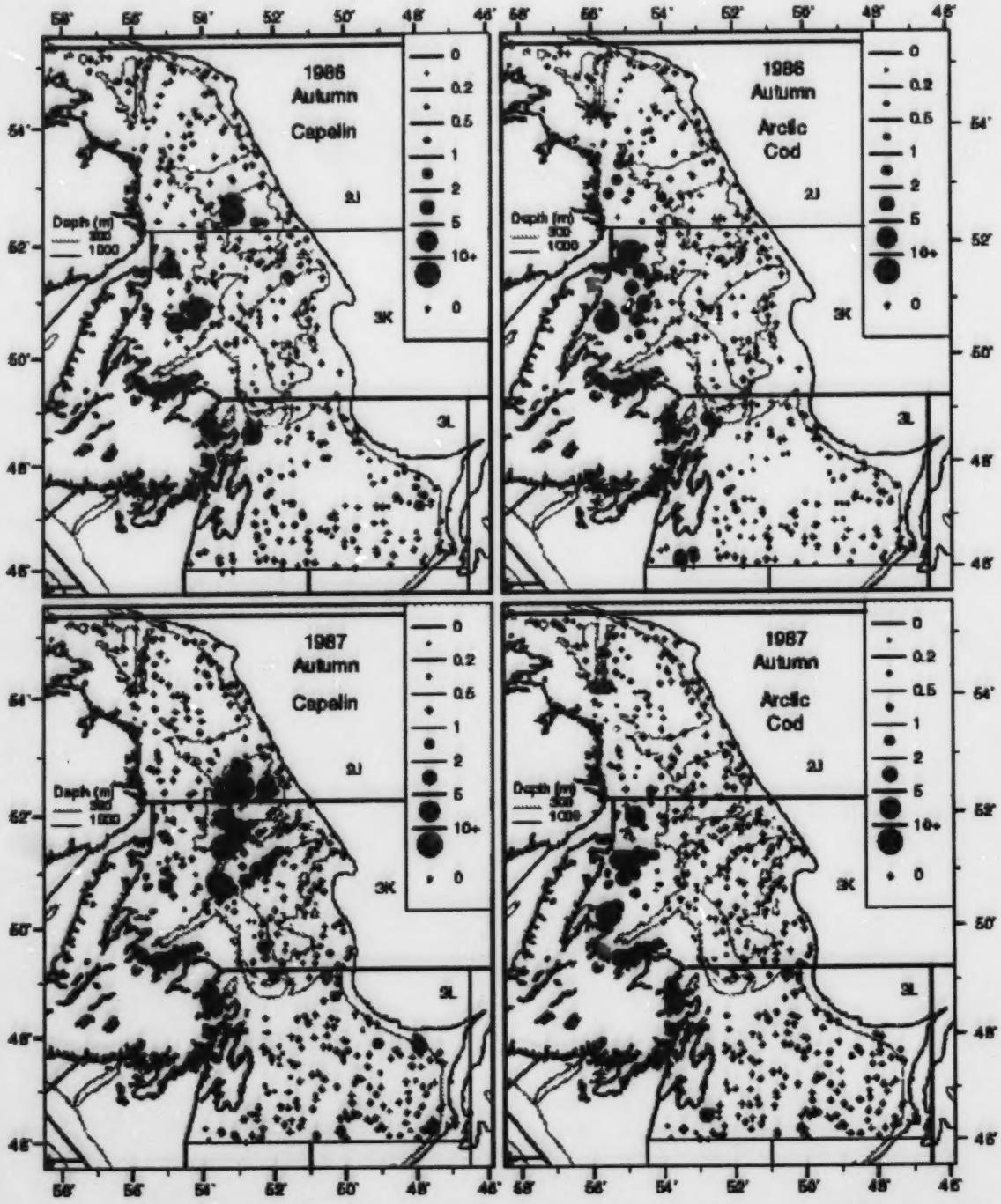


Fig. 1e. Geographic distribution [kg per 30 min tow (1978-1994) or 15 min tow (1995)] of capelin and Arctic cod in Divisions 2J3KL during the autumns of 1986 and 1987.

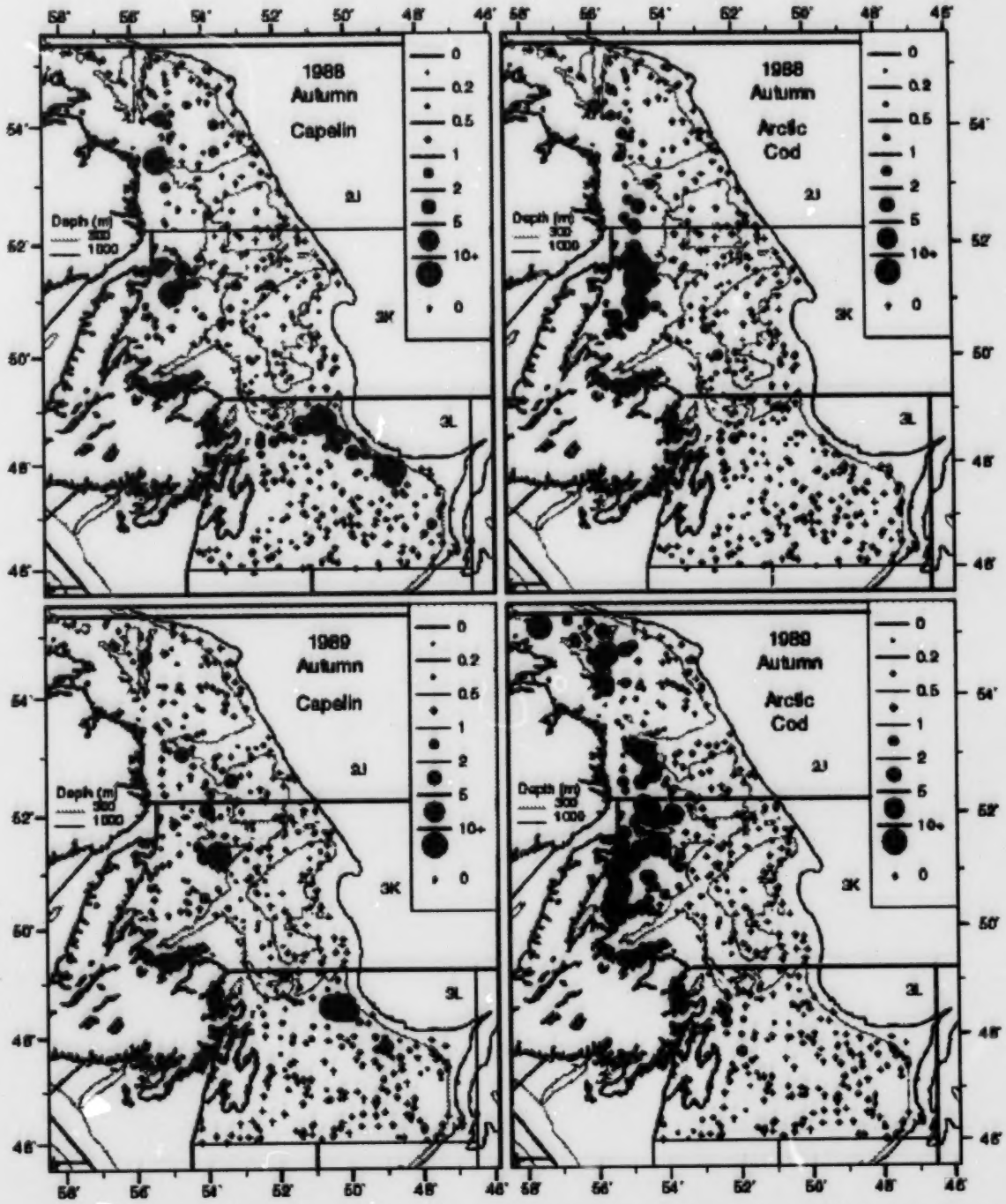


Fig. 1f. Geographic distribution [kg per 30 min tow (1978-1994) or 15 min tow (1995)] of capelin and Arctic cod in Divisions 2J3KL during the autumns of 1988 and 1989.

Fig. 1g. Geographic distribution [kg per 30 min tow (1978-1994) or 15 min tow (1995)] of capelin and Arctic cod in Divisions 2J3KL during the autumns of 1990 and 1991.

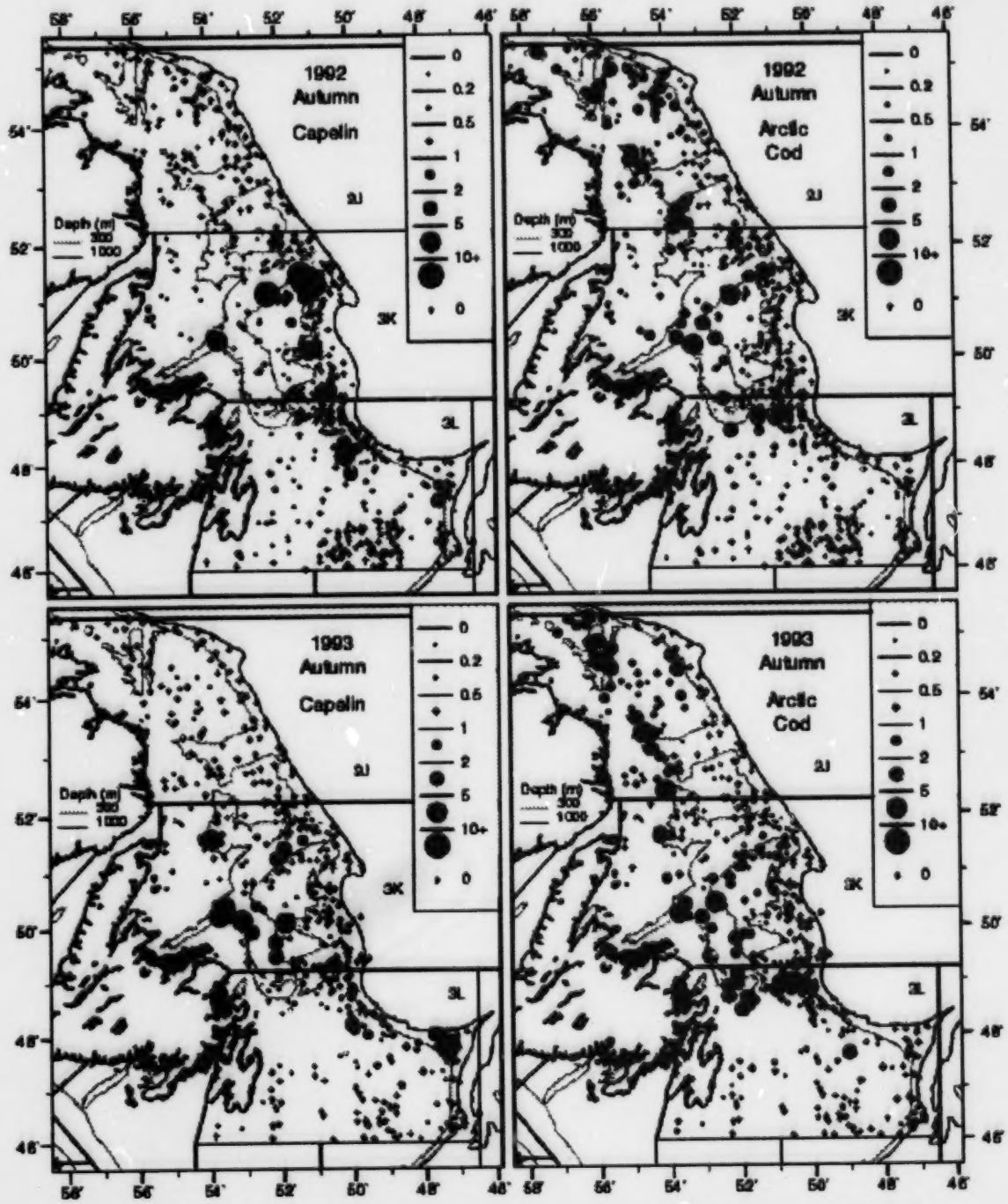


Fig. 1h. Geographic distribution [kg per 30 min tow (1978-1994) or 15 min tow (1995)] of capelin and Arctic cod in Divisions 2J3KL during the autumns of 1992 and 1993.

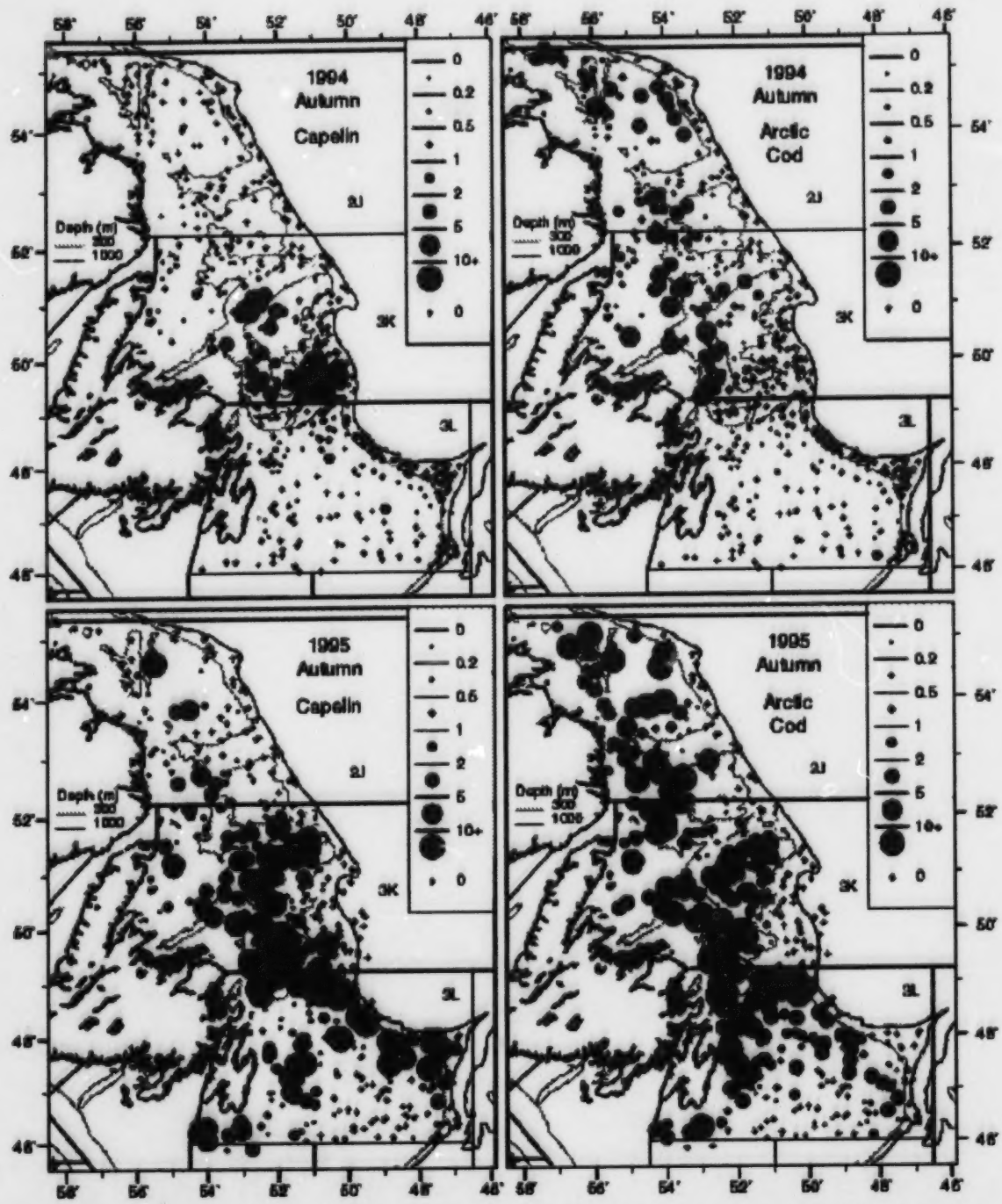


Fig. 1i. Geographic distribution [kg per 30 min tow (1978-1994) or 15 min tow (1995)] of capelin and Arctic cod in Divisions 2J3KL during the autumns of 1994 and 1995.

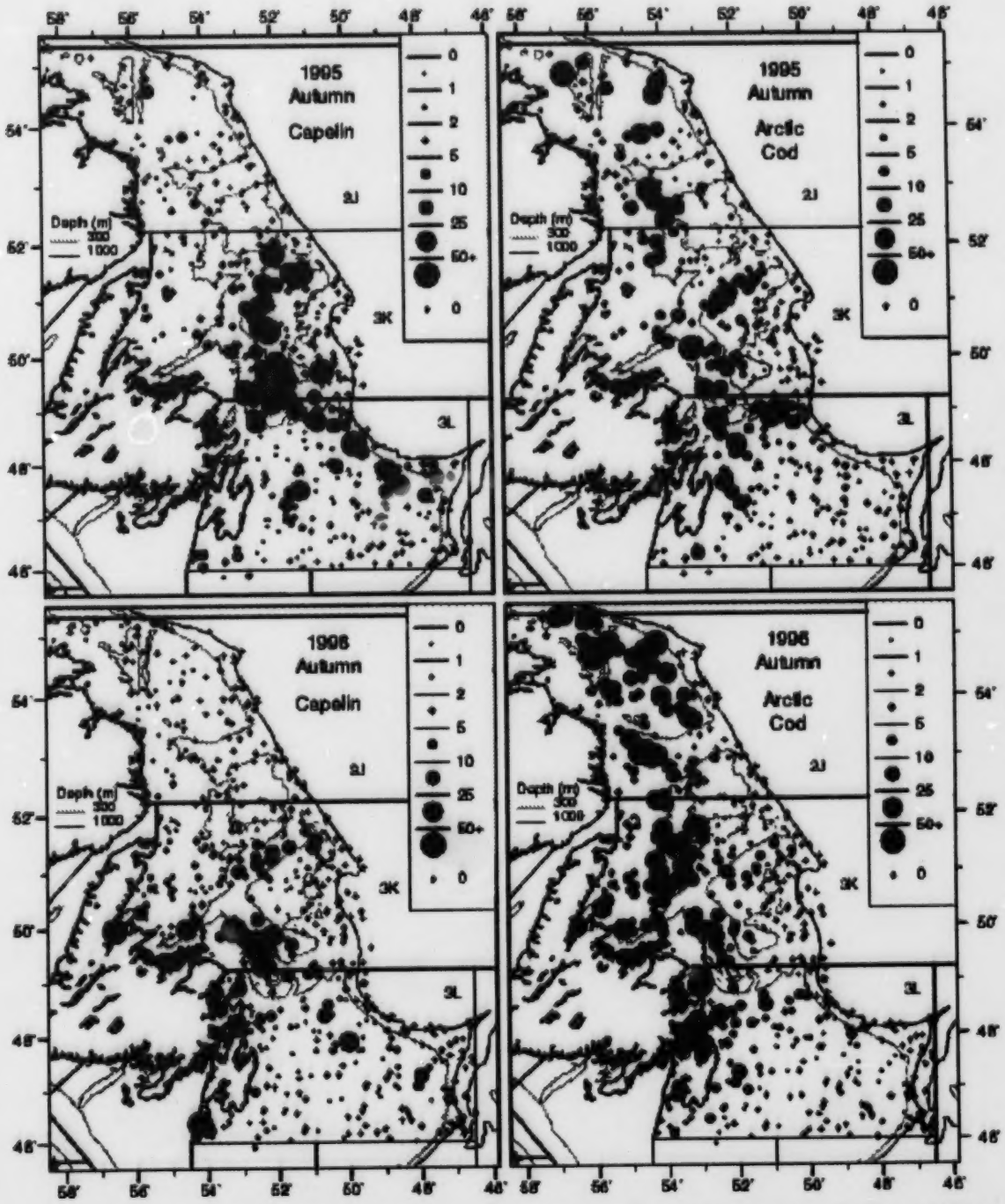


Fig. 2a. Geographic distribution (kg per 15 min tow) of capelin and Arctic cod in Divisions 2J3KL during the autumns of 1995 and 1996. Note that the scale has changed from Fig. 1.

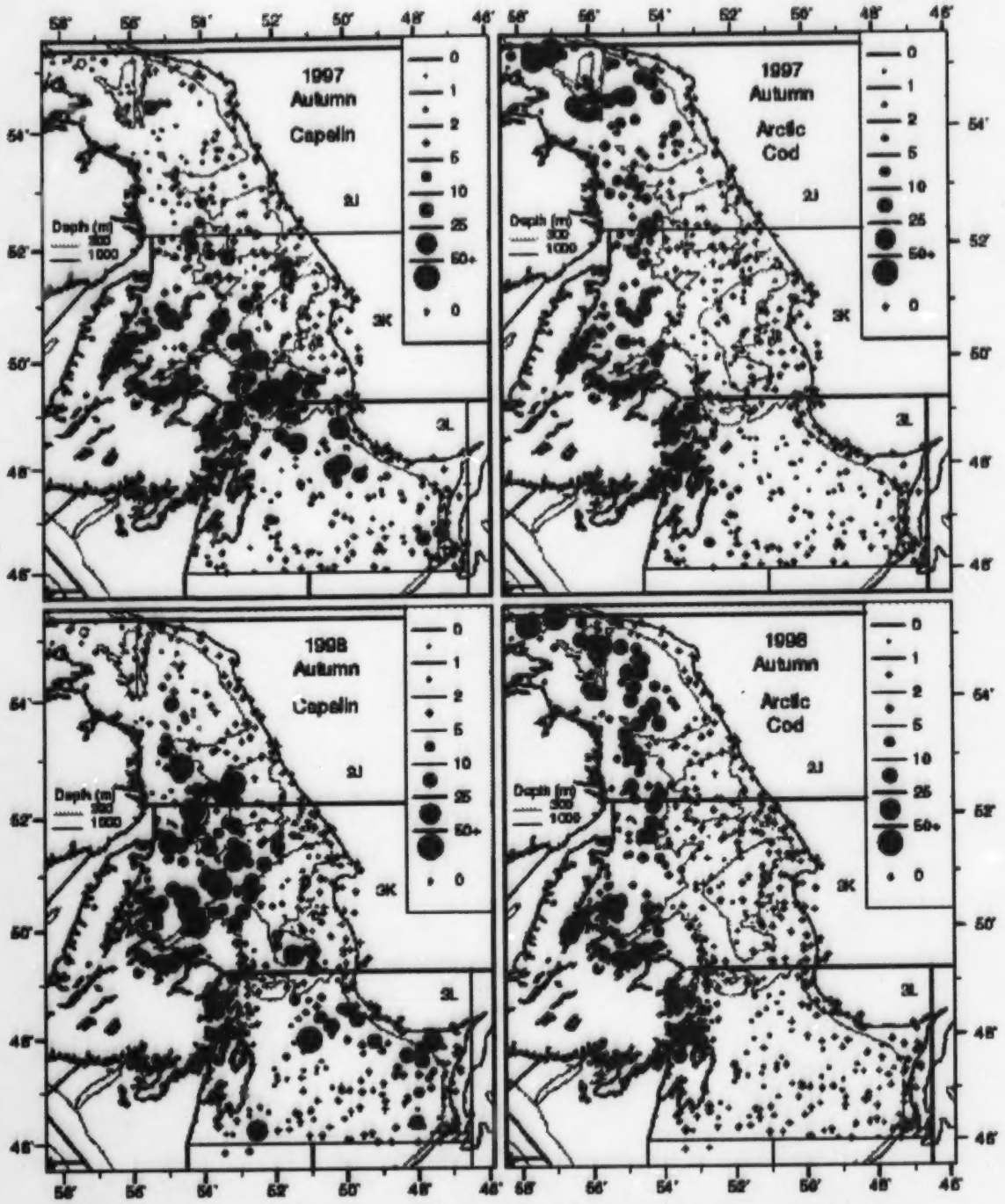


Fig. 2b. Geographic distribution (kg per 15 min tow) of capelin and Arctic cod in Divisions 2J3KL during the autumns of 1997 and 1998. Note that the scale has changed from Fig. 1.

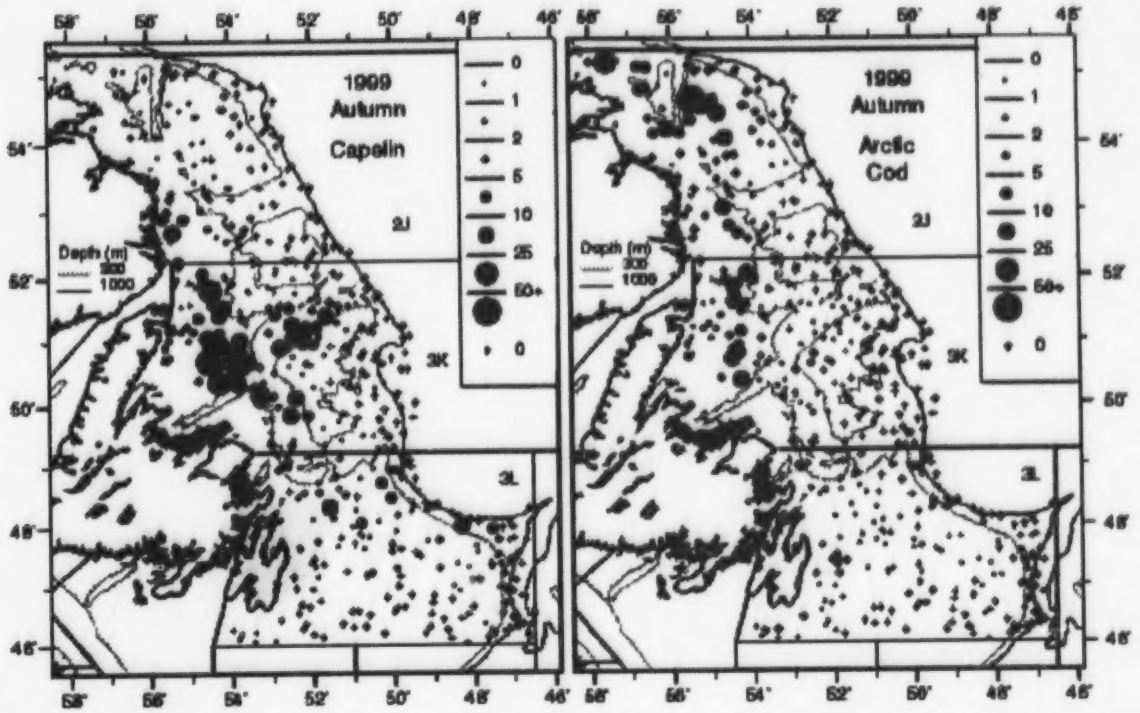


Fig. 2c. Geographic distribution (kg per 15 min tow) of capelin and Arctic cod in Divisions 2J3KL during the autumn of 1999. Note that the scale has changed from Fig. 1.

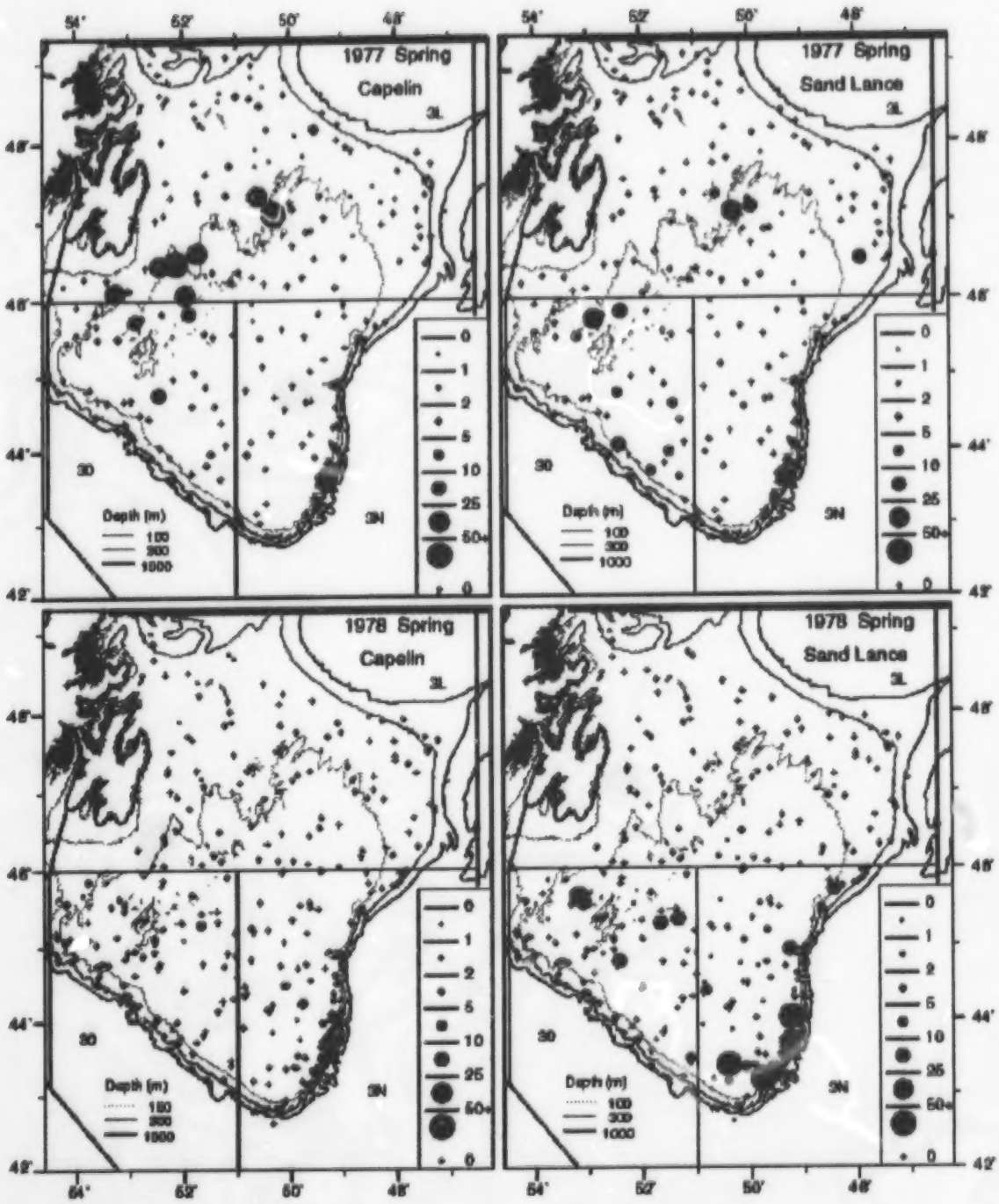


Fig. 3a. Geographic distribution (kg per 30 min tow) of capelin and sand lance in Divisions 3LNO during the springs of 1977 and 1978.

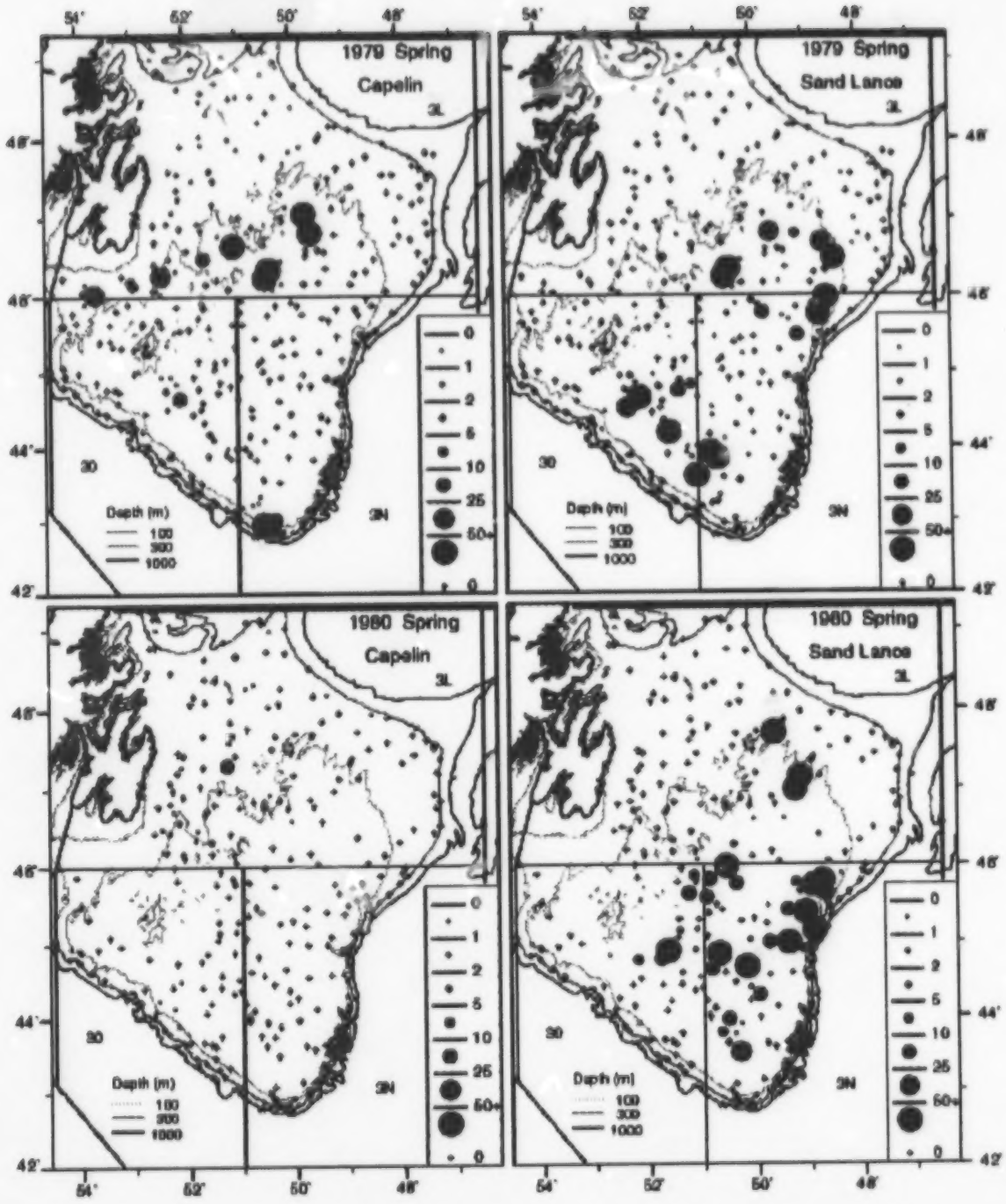


Fig. 3b. Geographic distribution (kg per 30 min tow) of capelin and sand lance in Divisions 3LNO during the springs of 1979 and 1980.

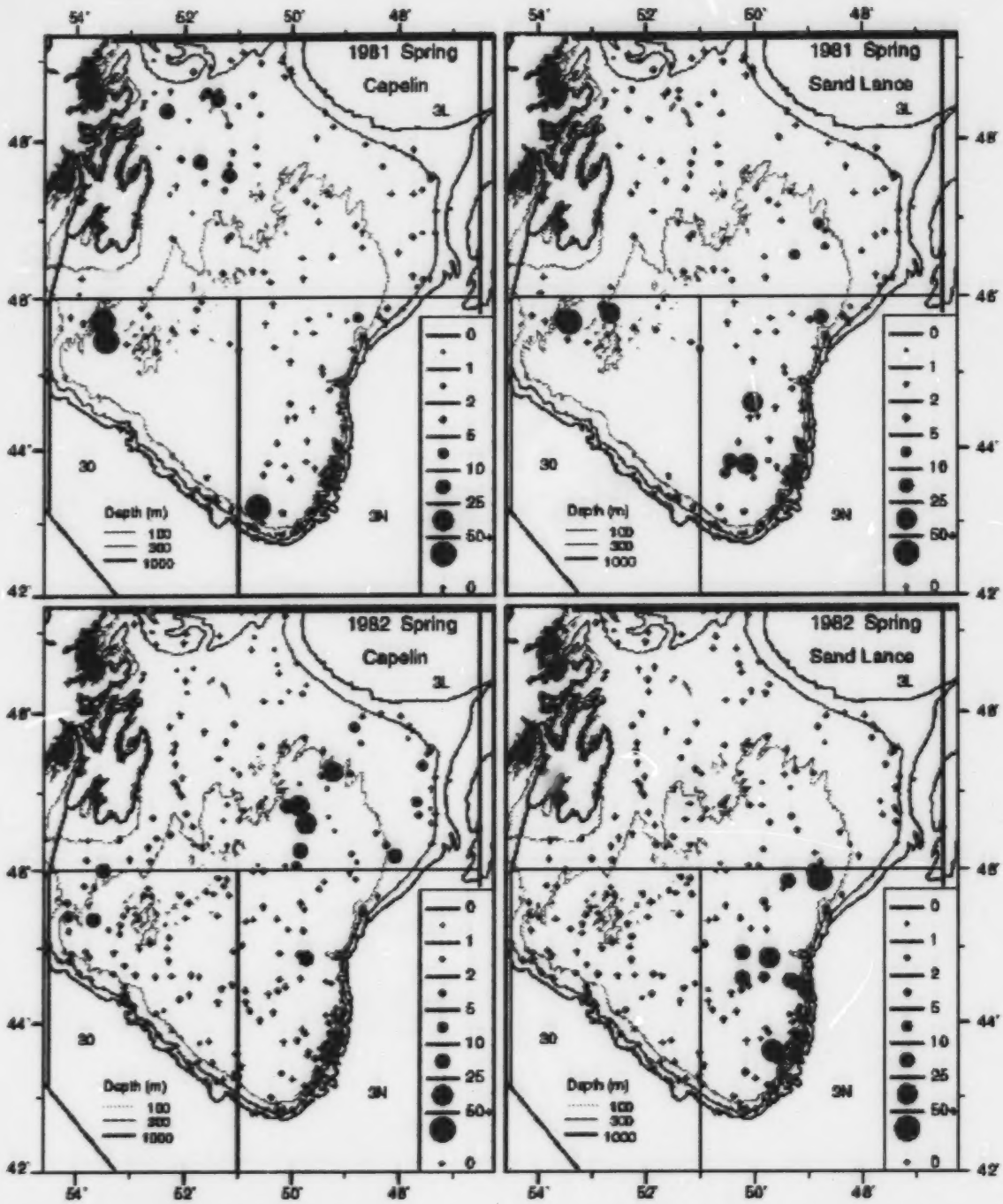


Fig. 3c. Geographic distribution (kg per 30 min tow) of capelin and sand lance in Divisions 3LNO during the springs of 1981 and 1982.

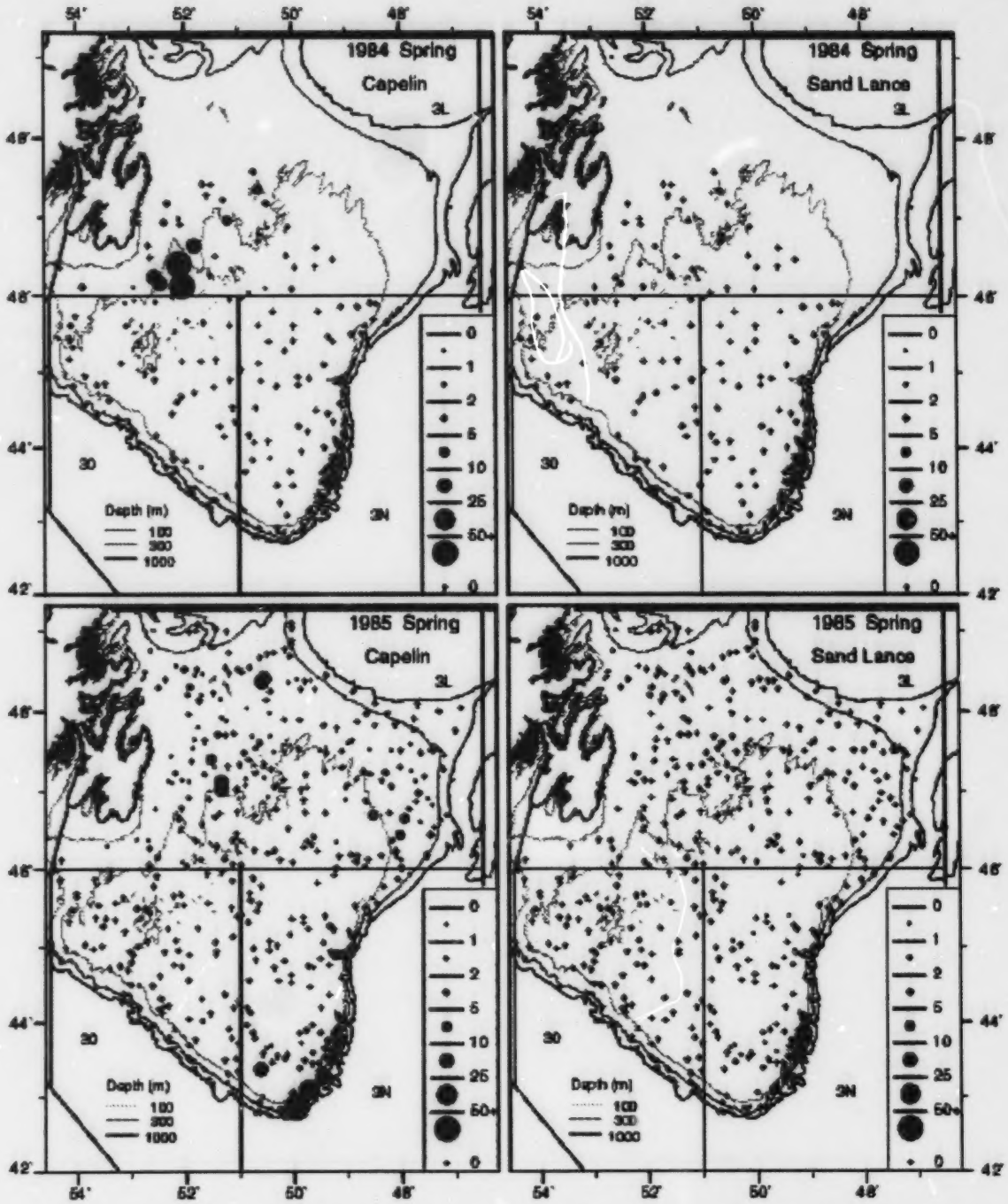


Fig. 3d. Geographic distribution (kg per 30 min tow) of capelin and sand lance in Divisions 3LNO during the springs of 1984 and 1985.

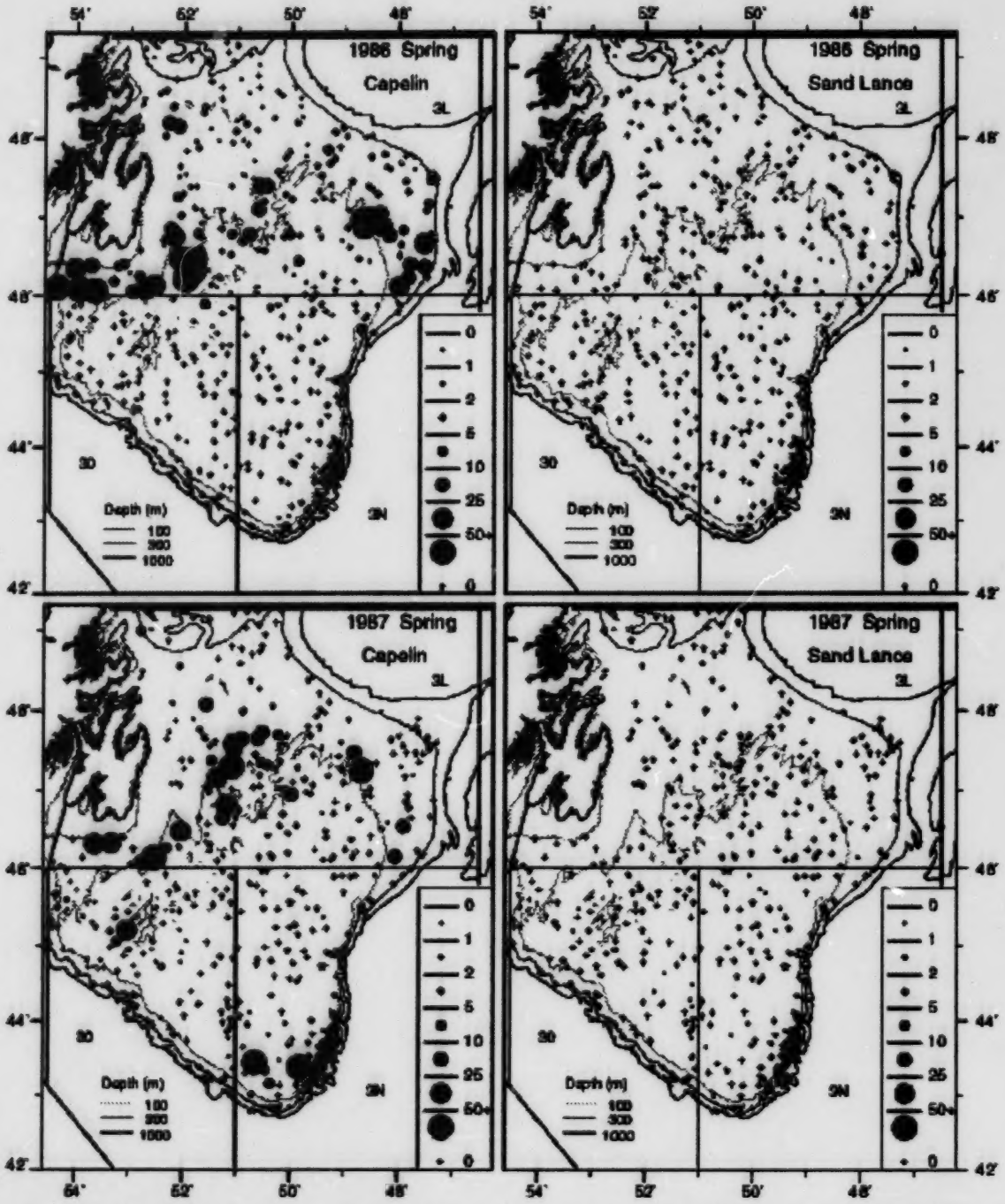


Fig. 3e. Geographic distribution (kg per 30 min tow) of capelin and sand lance in Divisions 3LNO during the springs of 1986 and 1987.

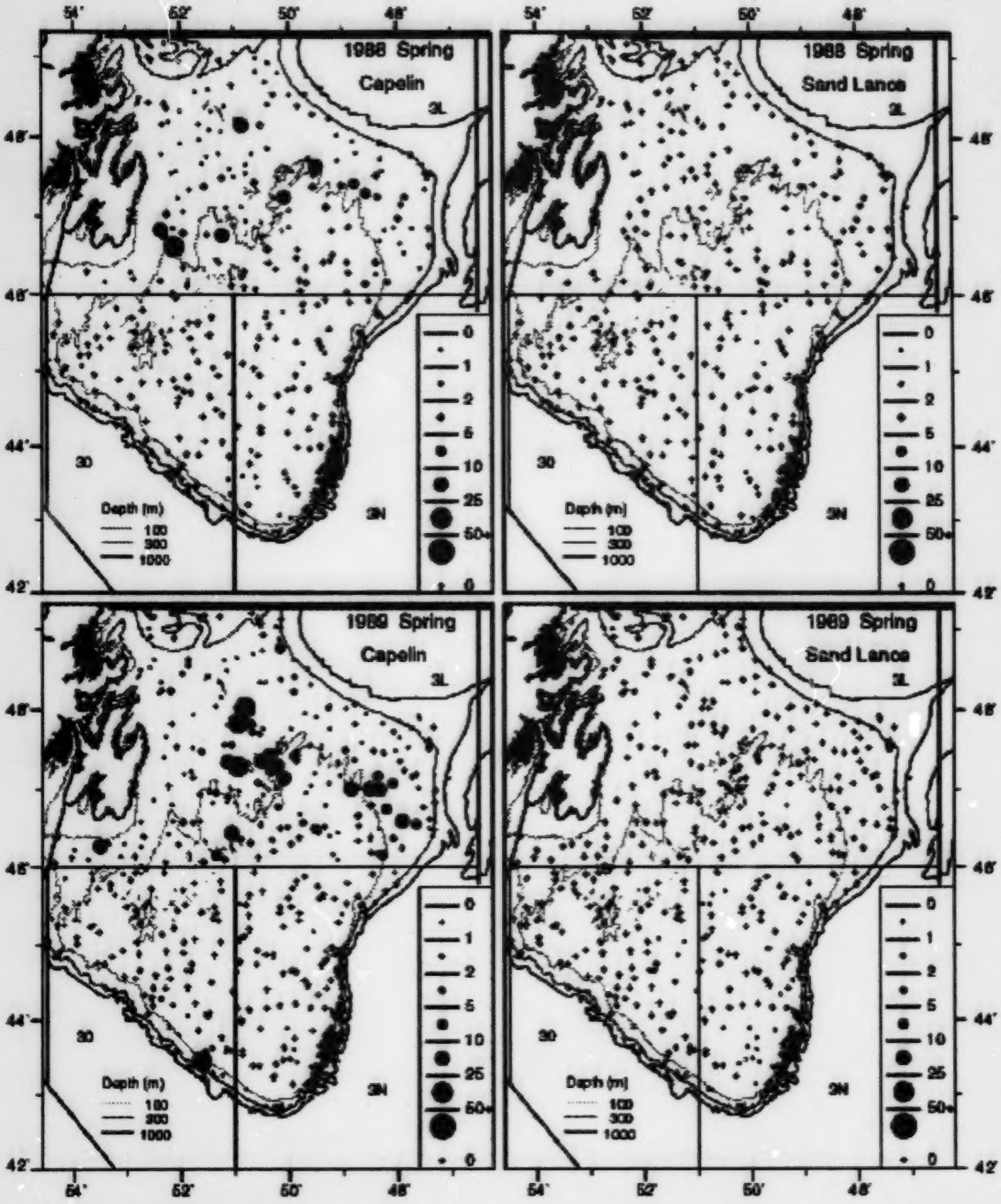


Fig. 3f. Geographic distribution (kg per 30 min tow) of capelin and sand lance in Divisions 3LNO during the springs of 1988 and 1989.

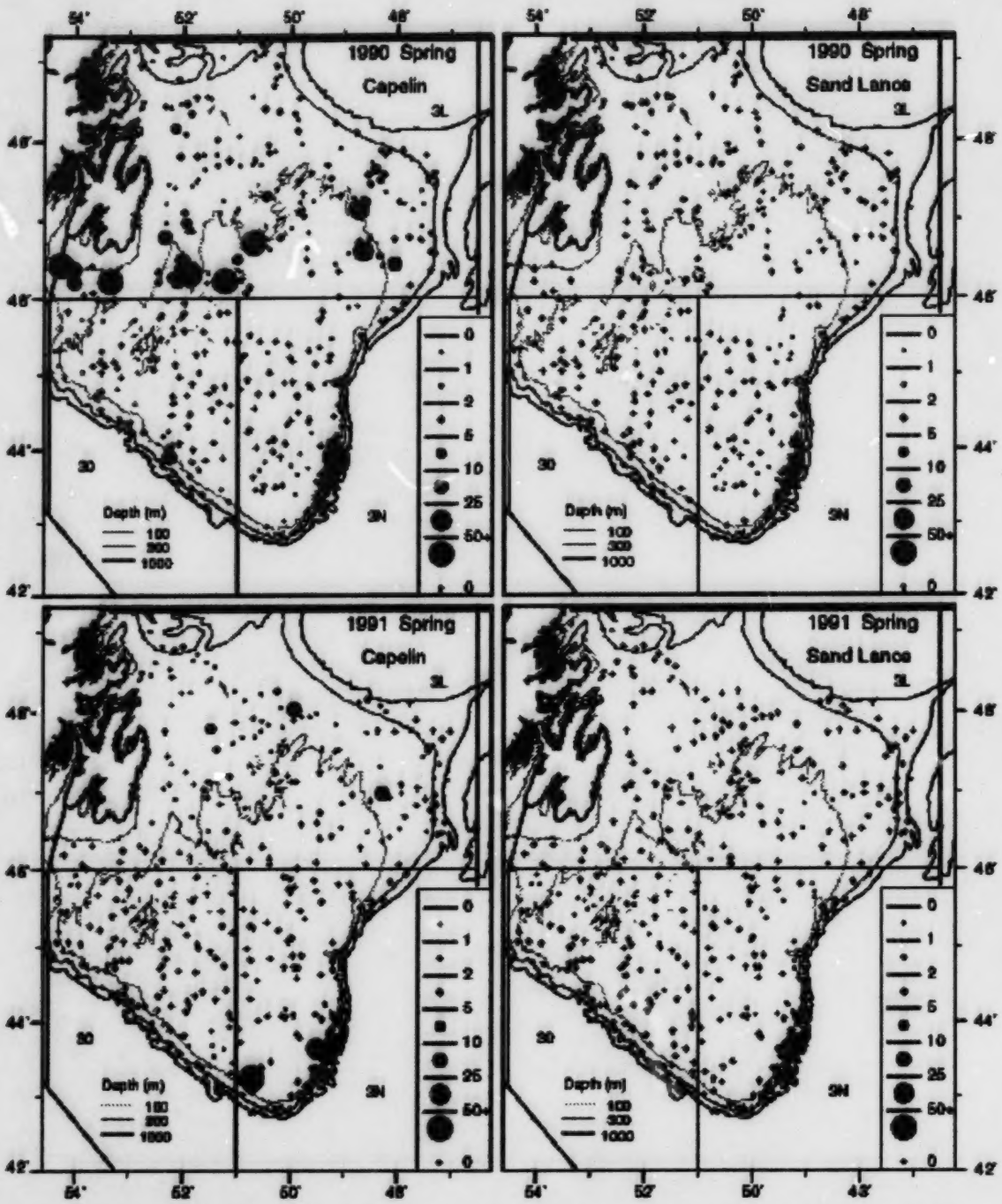


Fig. 3g. Geographic distribution (kg per 30 min tow) of capelin and sand lance in Divisions 3LNO during the springs of 1990 and 1991.

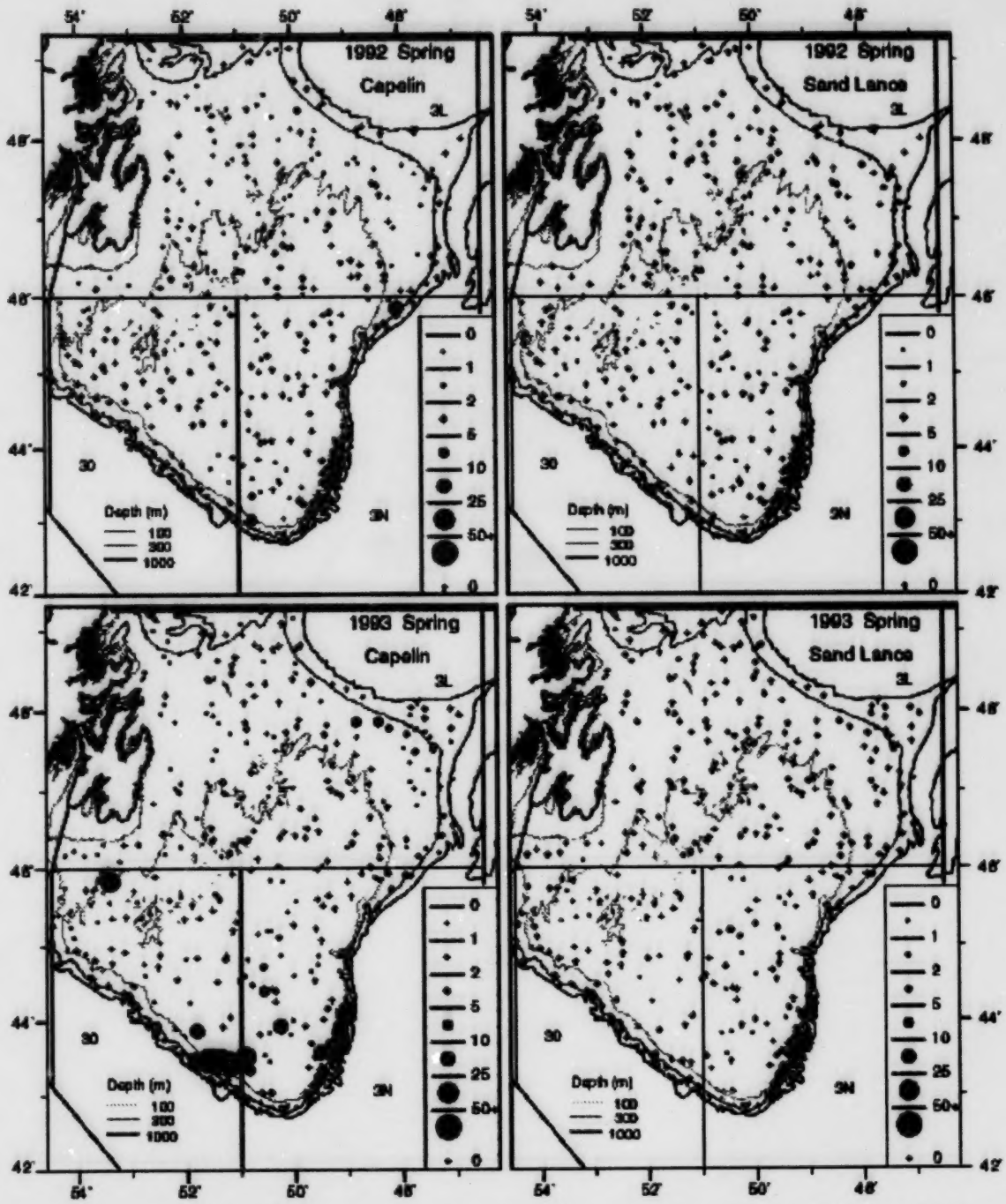


Fig. 3h. Geographic distribution (kg per 30 min tow) of capelin and sand lance in Divisions 3LNO during the springs of 1992 and 1993.

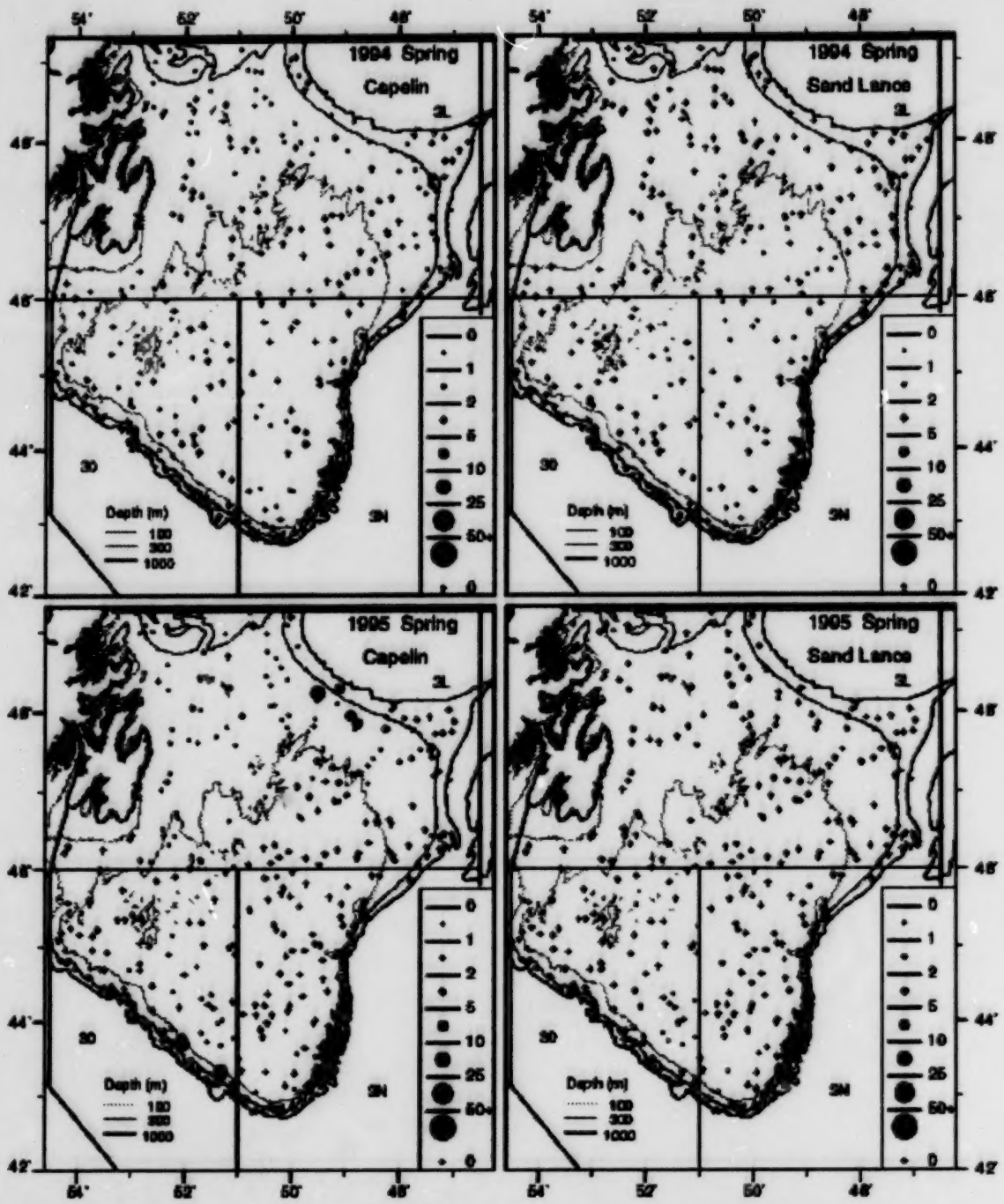


Fig. 3i. Geographic distribution (kg per 30 min tow) of capelin and sand lance in Divisions 3LNO during the springs of 1994 and 1995.

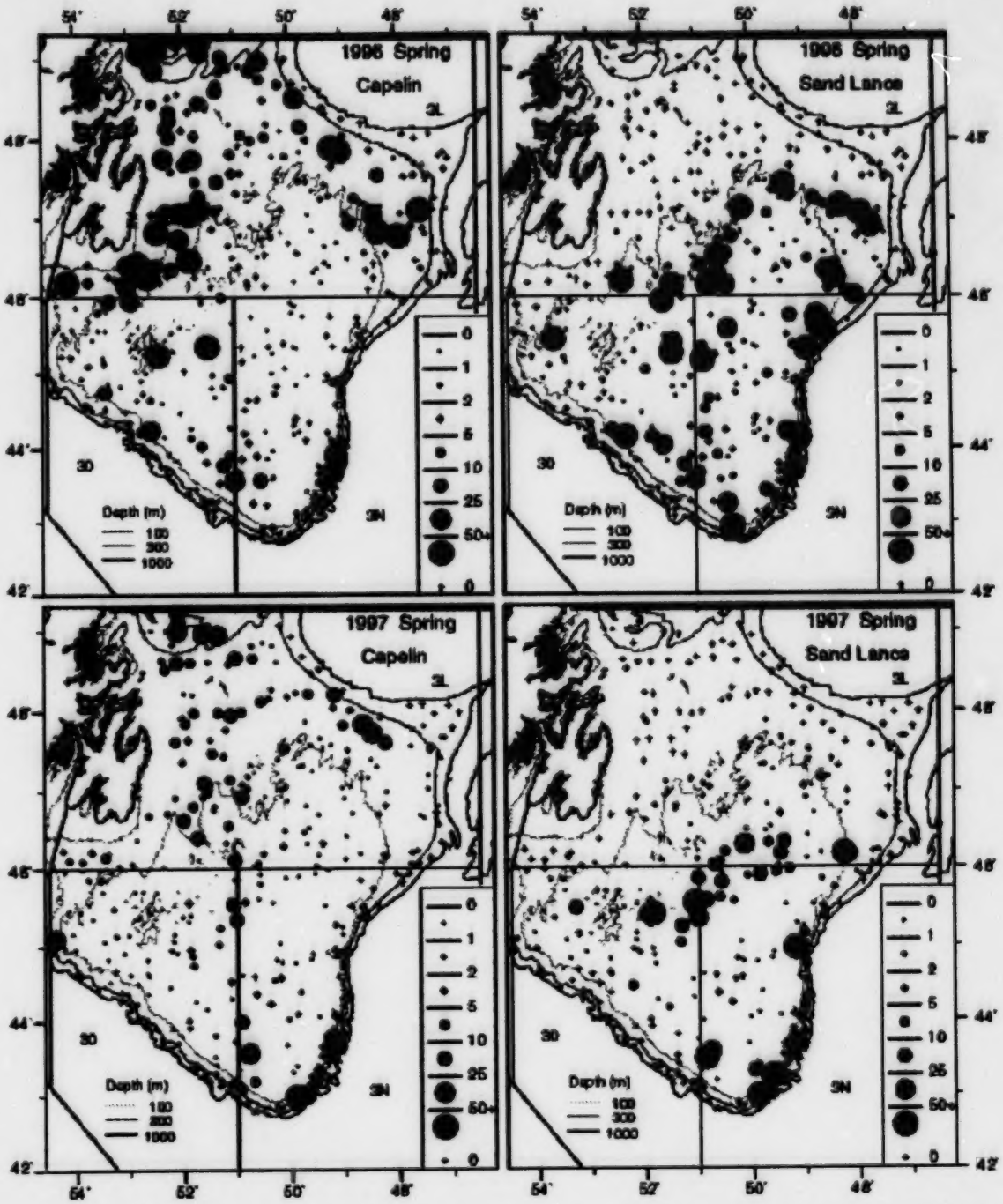


Fig. 4a. Geographic distribution (kg per 15 min tow) of capelin and sand lance in Divisions 3LNO during the springs of 1996 and 1997. Note that the scale has changed from Fig. 3.

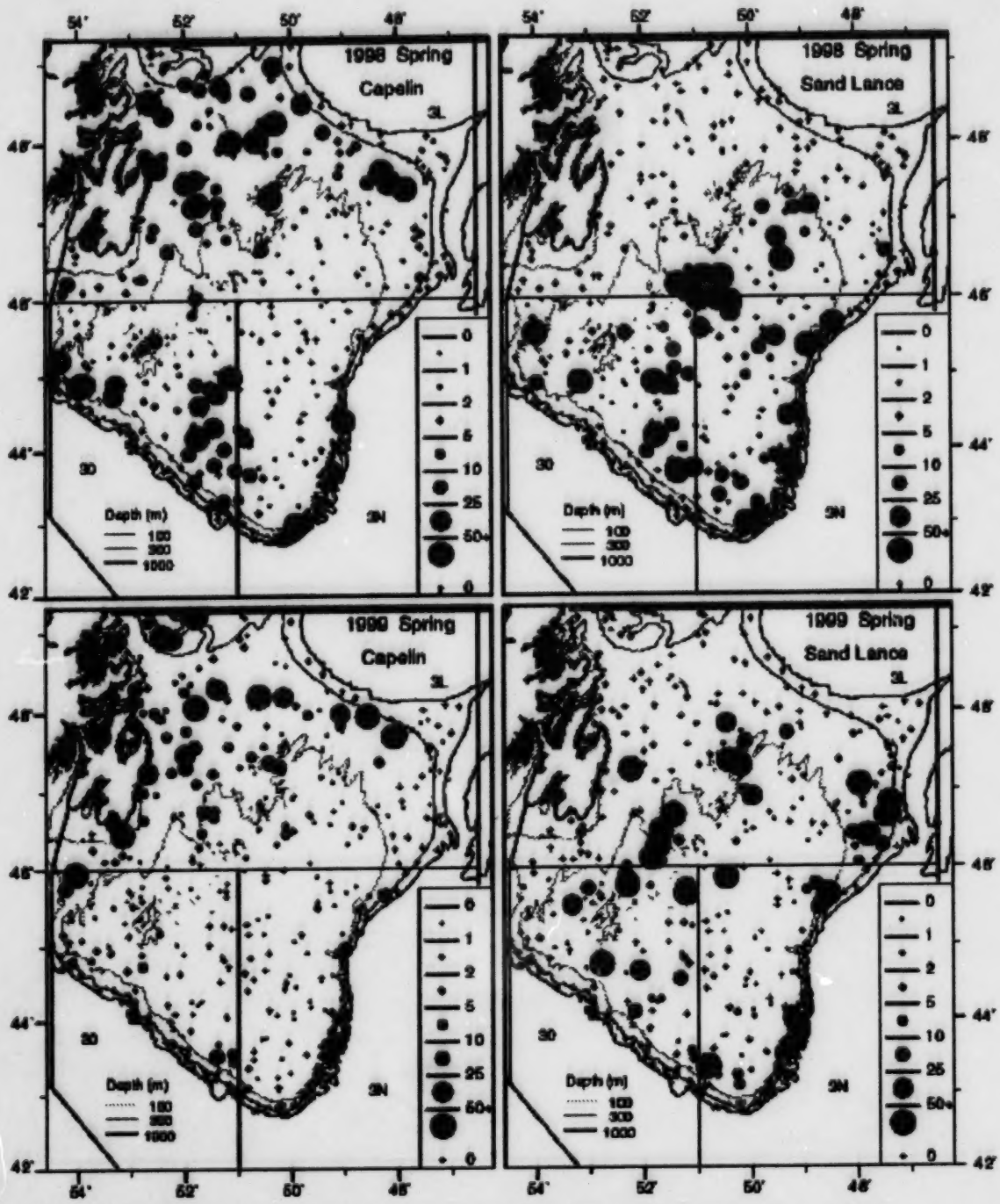


Fig. 4b. Geographic distribution (kg per 15 min tow) of capelin and sand lance in Divisions 3LNO during the springs of 1998 and 1999. Note that the scale has changed from Fig. 3.

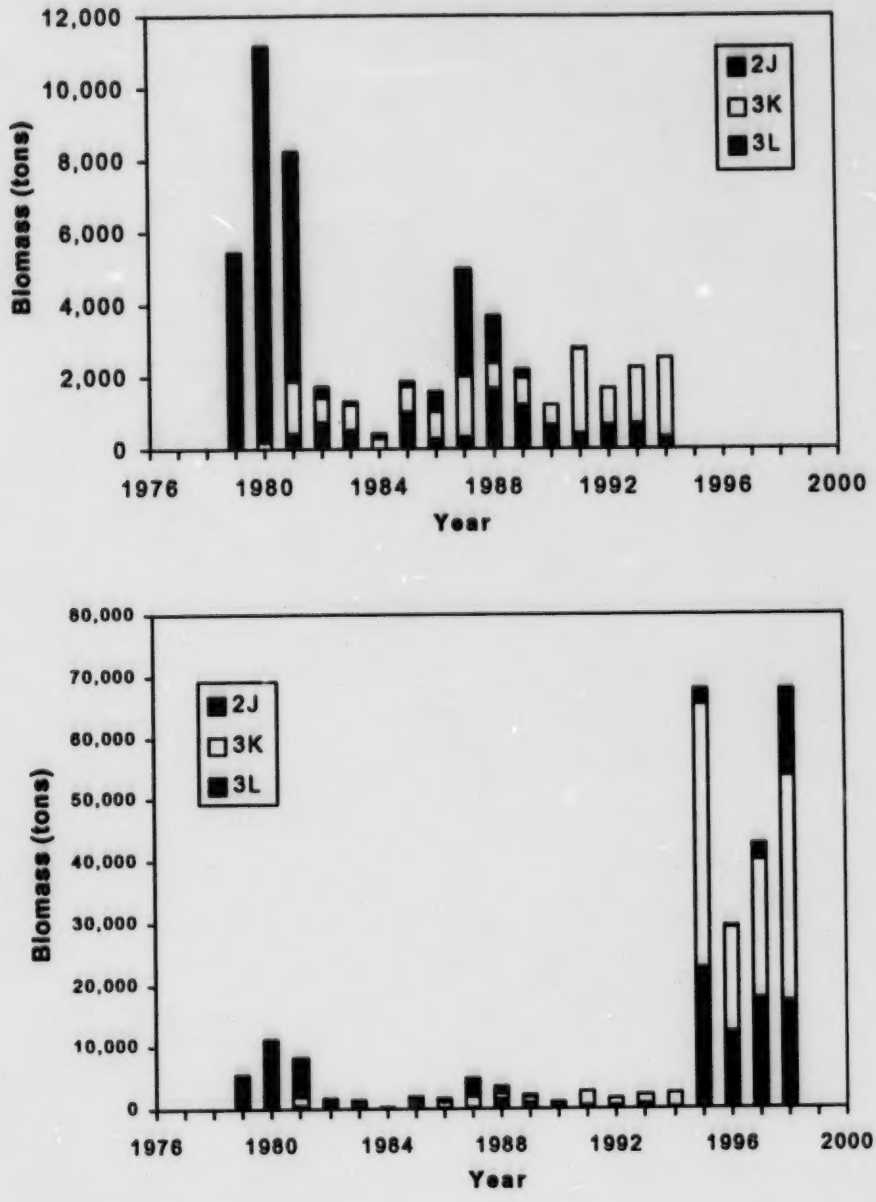


Fig. 5. Trawlable biomass estimates for capelin in Divisions 2J3KL during the autumns of 1978-1998.

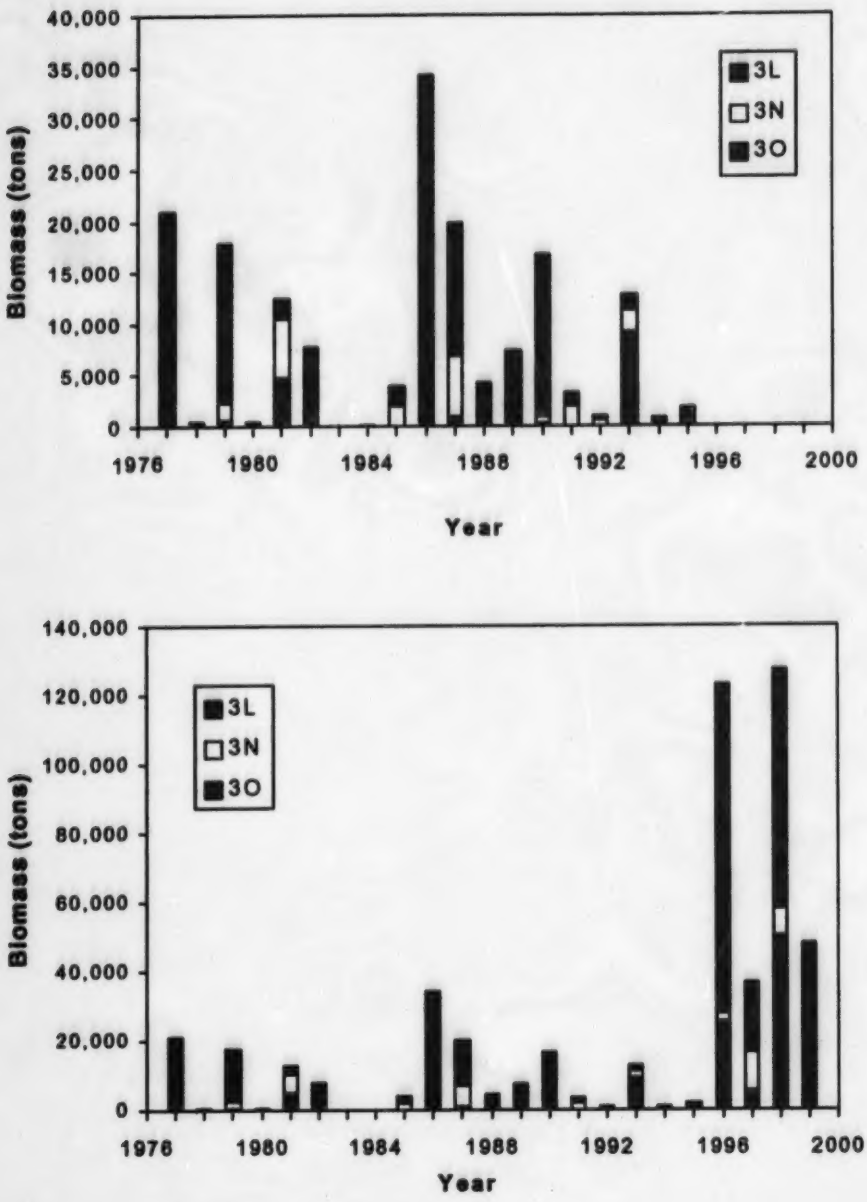


Fig. 6. Trawlable biomass estimates for capelin in Divisions 3LNO during the springs of 1977-1999.

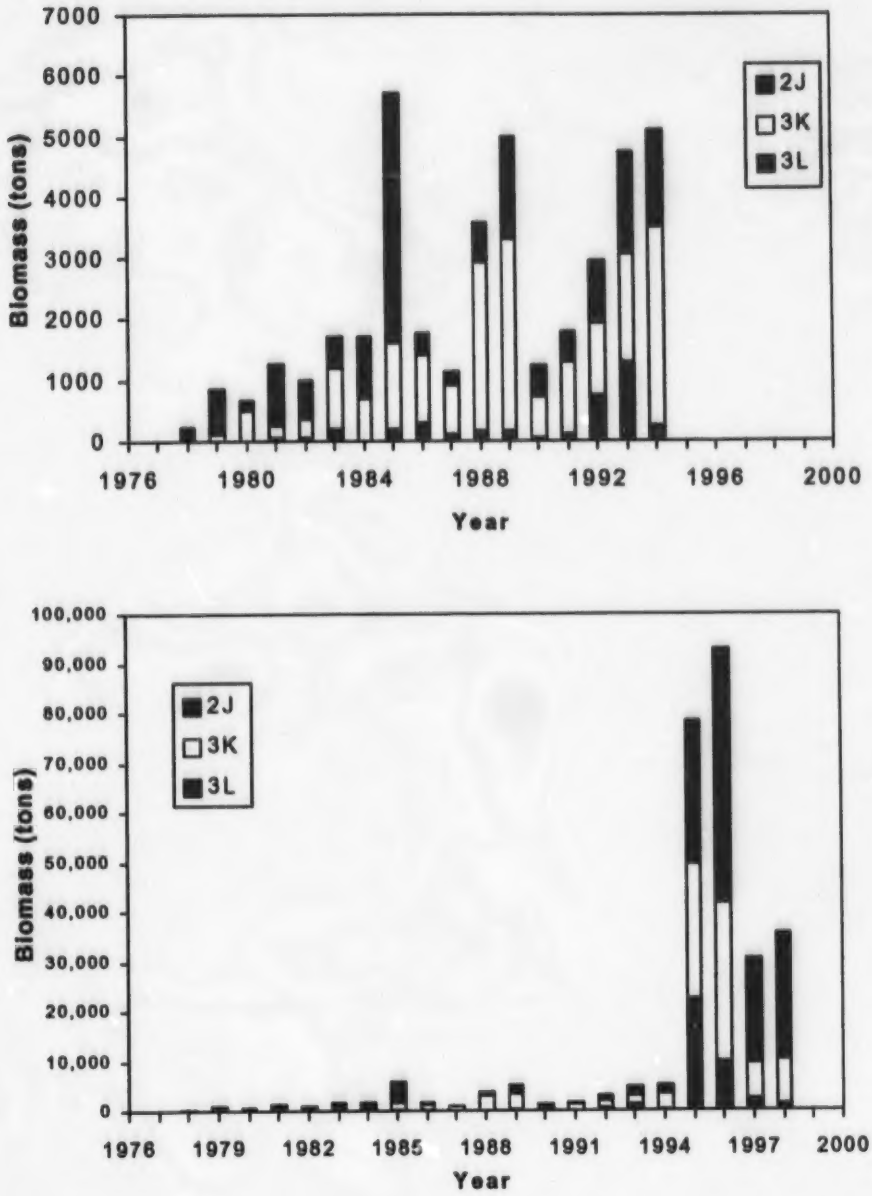
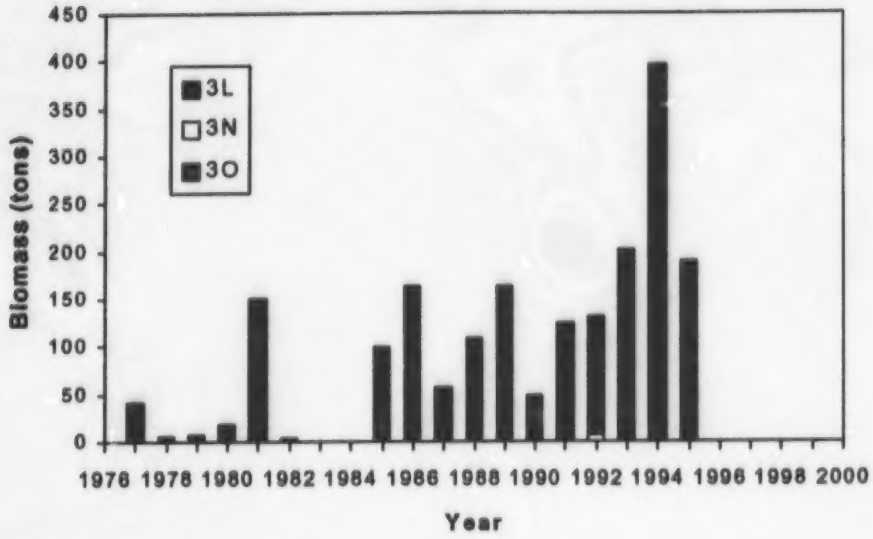


Fig. 7. Trawlable biomass estimates for Arctic cod in Divisions 2J3KL during the autumns of 1978-1998.



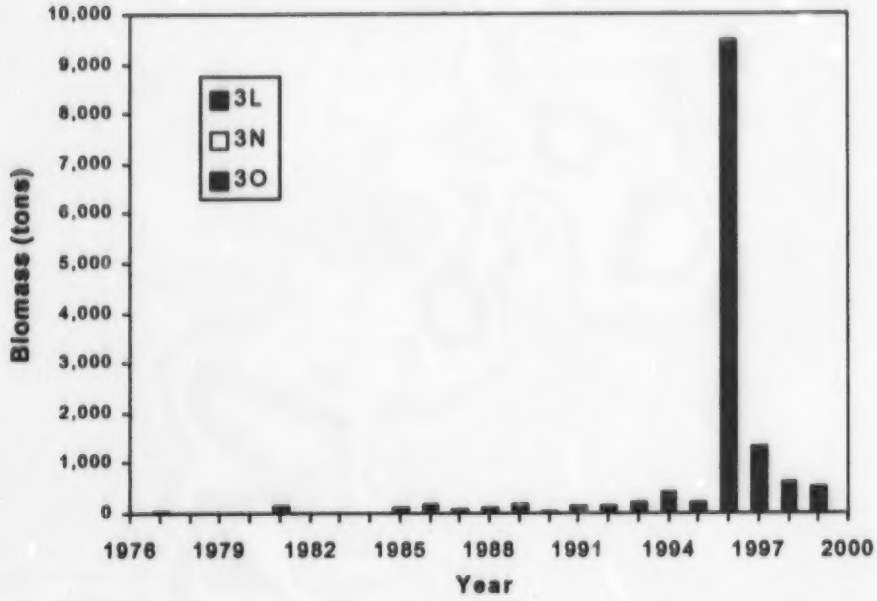


Fig. 8. Trawlable biomass estimates for Arctic cod in Divisions 3LNO during the springs of 1977-1999.

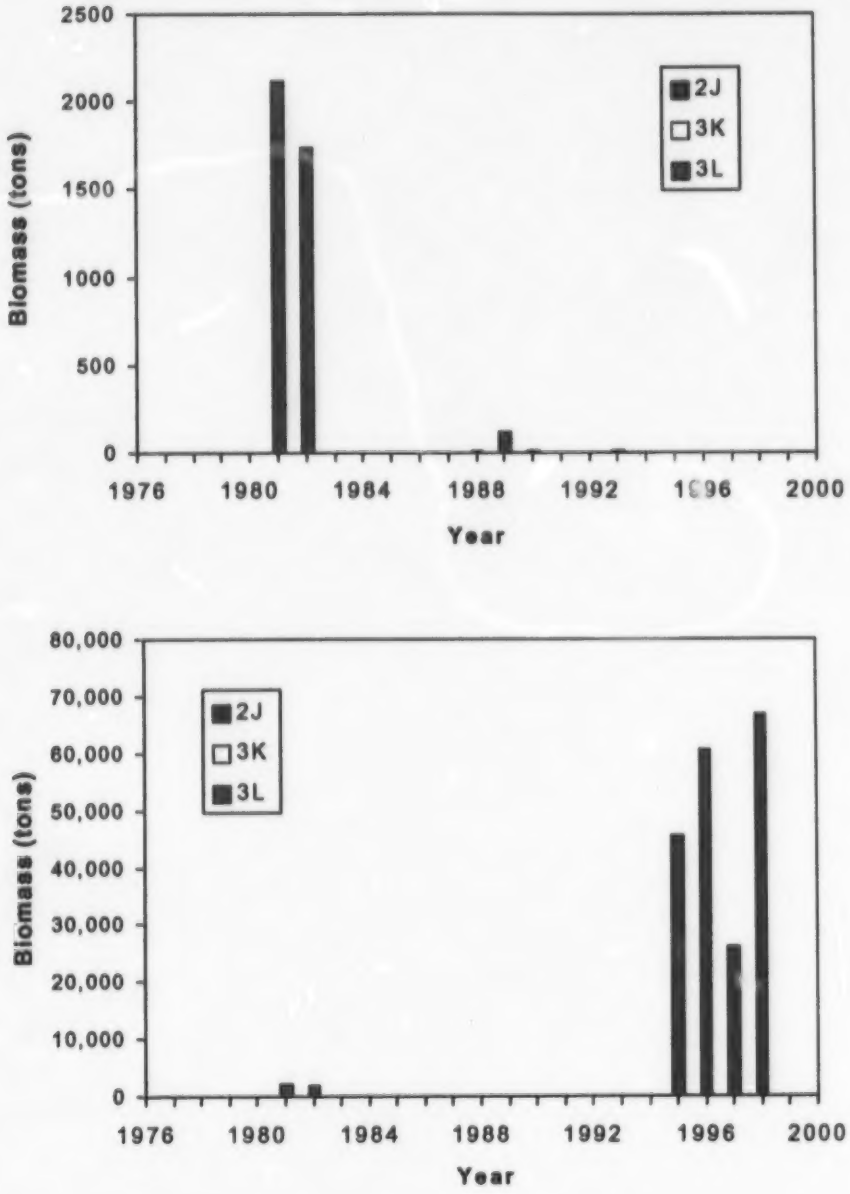


Fig. 9. Trawlable biomass estimates for sand lance in Divisions 2J3KL during the autumns of 1978-1998.

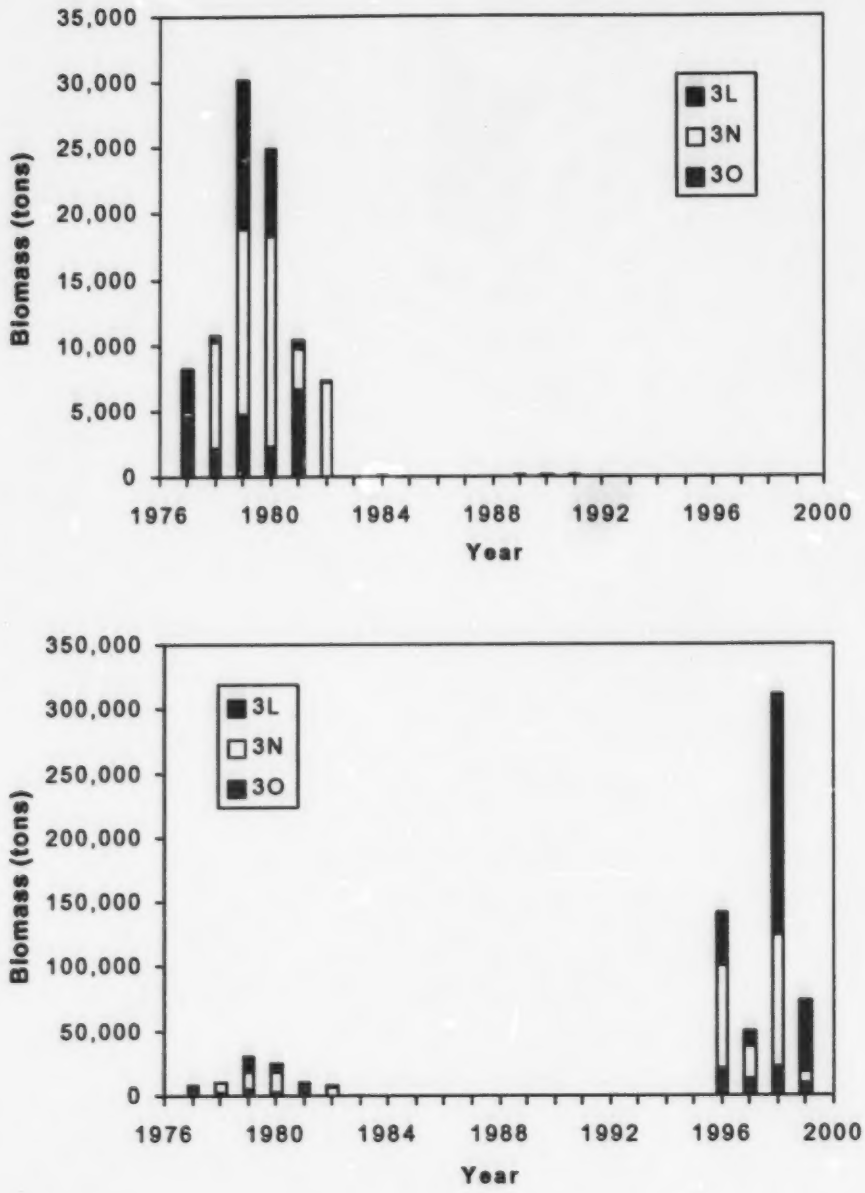


Fig. 10. Trawlable biomass estimates for sand lance in Divisions 3LNO during the springs of 1977-1999.